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GEORGE HENRY HEPTING: Pioneer Leader in Forest Pathology[1]

Ellis B. Cowling and Arthur Kelman
North Carolina State University, Raleigh, North Carolina 27695
e-mail: ellis_cowling@ncsu.edu; arthur_kelman@ncsu.edu

Harry R. Powers, Jr.
Southern Forest Experiment Station, U. S. Forest Service, Athens, Georgia 30602;
e-mail: hpowers@amanda.dorsai.org

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George Henry Hepting grew up in the city environment of Brooklyn, but early in his life developed a deep love and scientific interest in forestry. He became America's most skilled scientist in the theory and practice of forest pathology. He studied how long-lived forest trees, unlike most plants, cope with the long-term changes in their biological, physical, and chemical environments. He devoted his remarkably energetic life to learning, understanding, and teaching how trees survive disease stresses induced by biotic and abiotic agents—in forest nurseries, as individual trees, in young sapling stands, in naturally regenerated and planted stands, in old-growth forests, and in landscapes and watersheds. He focused his innovative spirit, curiosity, and high intelligence on seeking ways to use this understanding to develop practical guidelines for management that can be used to decrease or minimize disease losses and deterioration of wood in service. From the research that he and his close co-workers completed have come many tangible benefits. Throughout his life, Hepting was devoted to maintaining the rich biological heritage of this country in its forests and wildlife resources, in national, state, and city parks, and trees in residential, commercial, and recreational landscapes—resources that are important, not only to the economic vitality, but also for the spirit and aesthetic quality of life in the United States.

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Personal History

George Hepting was born in Brooklyn, New York, on September 1, 1907. After attending public schools in Brooklyn, he completed his undergraduate studies in forestry at Cornell University in 1929. One of Hepting's most inspiring undergraduate teachers was the noted plant pathologist, Dr. HH Whetzel. In an unpublished autobiography, Hepting described how he decided to become a forest pathologist:

> Two of my required courses were general plant pathology and forest pathology. Through these courses I came under the influence of Professor H. H. Whetzel. I soon found myself developing a strong interest in his courses. The ills of trees, like the ills of mankind, fascinated me. I was astounded to learn that in the short space of twenty-five years, a disease (chestnut blight), carried from the Orient, had started in our chestnut trees in New York and had swept completely through the eastern states to Alabama, on its way exterminating this valuable species. White pine blister rust, the Dutch elm disease and many others were well on their way to destroying millions of dollars worth of timber and street trees in a matter of a few years. Here was something for me. Here was a field of work in which a man would work with trees. I discovered that the US Department of Agriculture had a Division of Forest Pathology, with about fifty technical men scattered the length and breadth of the country, doing research on tree diseases, and that an occasional state or university had a man or two who spent some time on tree diseases.
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> This handful of men, armed with the limited knowledge of a new profession, was trying to solve the multitude of problems in forest pathology. In addition to the hundreds of native diseases that did a tremendous amount of cumulative damage, serious new major diseases were appearing in the country at an alarming rate of about one every five years. I resolved to be a forest pathologist if I could find a place in this tiny field. Professor Whetzel encouraged me and offered me valuable assistance. This time I knew the kind of work that I would be doing and that I would like it.

Even before completing his PhD degree at Cornell in 1933, Hepting joined this tiny cadre of scientists in the US Department of Agriculture who were charged with protecting US forests against disease. He remained with the Division of Forest Disease Research throughout his professional life. After completing his doctorate on the heartrot diseases of forest trees, he rose through the ranks from Field Assistant in 1931, through Chief of the Division of Forest Disease Research at the Southeastern Forest Experiment Station from 1953 to 1961, to Principal Research Scientist affiliated with the Forest Service's Washington office from 1962 to 1971, but assigned mainly to the Southeastern Forest Experiment Station in Asheville, North Carolina. He retired from the Forest Service as Chief Plant Pathologist in 1971. From 1967 through 1984, he served as a Visiting Professor in the Department of Plant Pathology and the School of Forest Resources at North Carolina State University. He died on April 20, 1988.

During much of his life, Hepting had to cope with a series of illnesses requiring surgery and a series of hospitalizations with continuing complex medical problems and twice-daily medications that would have drastically limited the productivity of most individuals. Few people, other than close colleagues and family members, were cognizant of the full extent and seriousness of these problems. Because of Hepting's strong will and remarkable personal courage, he always remained fully committed to his profession and related responsibilities.

Although deeply involved in his professional life, Hepting greatly enjoyed as a hobby the selection and polishing of unique gem stones. As was typical of all his activities, he perfected his techniques and became very knowledgeable and recognized for his proficiency in this field.

In 1936, George Hepting married Anna Love Hepting, who predeceased him on May 13, 1986. Both are buried in the Lewis Memorial Cemetery in Asheville, North Carolina. Dr. Hepting is survived by his sister, Aimee Hepting of Syosett, New York, and two sons, George Carleton Hepting of New York City and John Bartram Hepting, who was named for John Bartram, a distinguished horticulturist and world-renowned botanist of Philadelphia and a direct ancestor of Anna Love Hepting.

The Department of Plant Pathology at North Carolina State University maintains a file of his nearly 200 scientific publications, his extensive library of nearly 2000 reprints and books, and copies of the fascinating and often humorous autobiographical résumé of the first half of his career.

Professional Accomplishments

The range of disease and timber deterioration problems in which Hepting became involved represents a remarkable scope in terms of the diversity of fungi involved and complexity of factors to be considered in developing effective means of reducing losses. Only a few examples of his many contributions will be noted in detail.

Hepting's first research project was on heartrot in Mississippi Delta hardwoods (2). He determined the impact of fire scars, basal wounds, and stump sprouts on infection and spread of decay in many species of trees (16, 18, 19, 24, 26). He was the first to describe the remarkable mechanisms by which trees restrict the development of decay and discoloration in stems to "tissues extant at time of wounding" (14). This phenomenon provided the foundation for processes now known as compartmentalization. His research on decay and discolorations in hardwoods resulted in a Farmer's Bulletin that established a set of sound principles for effective management of Eastern hardwood forests (4). This bulletin was used extensively by the Civilian Conservation Corps (CCC) as a guideline for the efforts this organization instituted for management of federal forests in which the CCC worked; it still serves as a basic guide for foresters in the management of hardwood forests.

Before and during World War II, Hepting studied fungal discolorations in felled timber and lumber of southern pines. He also quantified the impact of discolorations and decay on the strength of wood veneers used in military aircraft (22).

In his unpublished autobiography, he described his novel experiences in this new area of research for him and his colleagues:

> We, in forest pathology, did not have to look for war problems—they fell into our laps from all directions. Wood was a major war material and we in the Division of Forest Pathology had the greatest fund of information on wood's defects of any group in the nation. We knew about wood decay and how to prevent it.

Under Hepting's direction, the tiny group of men and women in his Division immediately shifted the emphasis of their work from tree disease investigations to studies of problems of wood in service. The Navy and Coast Guard wanted information on the prevention of decay in wooden boats, and they also planned to build some wooden airplanes and gliders. The Army was already building all-wood training planes, and contemplated wood gliders. Furthermore, they had costly wood-decay problems in buildings, truck bodies, and bridge timbers.

> By the time of World War II, there was a critical shortage in aircraft metals. Most of the available light metals were to go into combat planes—bombers and fighters, so that the great bulk of thousands of training planes would have to be made of wood. Gliders, of which we were to require a great number, were also to be made largely of wood. Yellow poplar, one of the most important aircraft veneer species, is subject to many discolorations in the living tree. Early in the war, most of this colored poplar wood was being discarded from the aircraft grades on suspicion that it was weak. Nobody knew for sure whether or not it was weak, but the manufacturers did not trust it, and the Army did not like the looks of it. I was asked to undertake a study to determine whether the discolorations so common in yellow-poplar really indicated decreased strength of wood. I immediately went to several veneer mills and obtained hundreds of samples, including all of the common discolorations and normal-colored wood as well. We carefully matched each discolored stick with an adjacent normal-colored stick and sent the samples to the Forest Products Laboratory for testing. When the results were analyzed, we found that the great bulk of discolored wood was normal in strength, and that only browns, indicating rot, were weak. These results were released promptly to the veneer industry, the aircraft industry, and the Army. The harmless discolorations were then accepted. The production of poplar aircraft veneer went up 25%.
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> Wooden gliders were being turned out in quantity. Since our training fields each had from one hundred to several hundred aircraft, space to house these great numbers of airplanes could not easily be provided. Therefore, they generally remained in the open all of the time, exposed to the elements. Since most of the kinds of wood used in aircraft were known to decay readily under conditions of high moisture and warmth, and since there was no tendency among manufacturers to treat this wood chemically against decay,

> it seemed to us that some serious decay problems might develop in our Army airplanes. In December of 1942 I asked my Chief, if he would let me go into the field and study the problem of deterioration in wooden military airplanes and gliders. He agreed that sooner or later the armed services would run into trouble from decay in aircraft, so he assigned me to this work and ordered me to report to the Army Air Forces Material Command at Wright Field to make arrangements for my surveys at Army fields.

Hepting visited dozens of Army airfields in the East, South, and Middle West, checking the all-wood airplanes and wooden parts of other aircraft for signs of decay. Subsequently, Hepting and his group discovered a number of the factors leading to decay problems and developed procedures to eliminate or reduce conditions favorable for decay. Technical orders were issued to improve the stringency of inspection and cleaning of drains in all-wood aircraft. Hundreds of planes were grounded for repairs and the prospects of serious accidents were avoided. Revised specifications were made for airplane manufacturers on improving the design of drainage systems. Thus, through the efforts of Hepting and his research group, the deterioration problems in wood aircraft were corrected early in the war (22). The importance of this valuable contribution to the war effort has not been fully recognized.

Upon completion of this excursion into problems of deterioration and decay of wood products in service, Hepting and his staff devoted their research to a series of problems affecting forest trees in the South.

Little-leaf disease of southern pines proved to be one of his greatest challenges (15). Hepting organized research teams to investigate different aspects of the problem and stimulated both industry and government to provide support for these efforts. Success in the search for causal factors and management practices were his reward for the years of research it took to understand the many possible but elusive causal agents involved. It was concluded that the little-leaf disease resulted from a progressive deficiency of nitrogen induced by a complex interaction between certain soil conditions, feeder-root pathogens, land-use practices, and stand density that developed in many shortleaf pine stands as the trees increased with age (1, 5, 15, 27).

A destructive wilt disease of mimosa began to cause high mortality in this species in North Carolina in the late 1930s (3). In Hepting's investigation of the problem, he identified the causal fungus as a previously undescribed species of *Fusarium*; his report of these studies was one of the first descriptions of a tree disease caused by a species in this taxonomic group. In the several decades that followed, it was not possible to develop a means of preventing spread of the pathogen and the disease essentially eliminated mimosa from Washington, DC to Alabama. Recognizing that the only effective means of control was the development of resistant cultivars, Hepting & Toole screened thousands of mimosa genotypes after World War II and discovered a number of highly resistant selections. From these selections the cultivars 'Charlotte' and 'Tryon' were developed (28). These

were patented, the patent assigned to the Secretary of Agriculture as required by law, and the two resistant cultivars were released to the nursery trade through the American Nurserymen's Association. Several decades after their release, these cultivars are still widely planted and continue to be resistant to the pathogen.

Hepting and co-workers discovered a number of previously undescribed diseases damaging southern tree species, including the pitch canker disease of southern pines (21). They also identified the specific causal fungi. Subsequently, they found that pine trees inoculated artificially with the pitch canker fungus were stimulated to increase flow of marketable oleoresin (6). This procedure was patented and also used commercially.

When the oak wilt disease began to spread in the southern United States, Hepting assumed a leadership role in the national effort to understand the biology and dissemination of the oak wilt fungus. He designed and supervised large-scale surveys to determine the extent of spread into Tennessee and western North Carolina (7). In the course of these efforts, he discovered the role of mating types in the life history of the oak wilt fungus, a finding that he considered one of his most personally satisfying scientific achievements (23).

In mid-career, Hepting had a key role in resolving a controversy concerning the use of antibiotics for control of white pine blister rust. In the late 1950s, a US Forest Service technician, employed in the white pine blister rust control project in Idaho, published a series of papers in which claims were made that an antibiotic (Actidione BR) sprayed as a basal application on blister rust cankers and a second antibiotic (Phytoactin) could effectively prevent development of the rust fungus in infected trees. Hepting became very skeptical about these findings. Studies were initiated by members of his staff (Harry Powers and others) to determine independently the effectiveness of these compounds in tests on white pines. In sharp contrast to the findings in Idaho, Powers' results indicated that application of antibiotics may reduce sporulation of the rust fungus, but did not eradicate the fungus in established infections. Actidione was also tested in the Southeast for the control of Fusiform rust, a destructive disease of southern pines similar to white pine blister rust in its effects on pine trees. Results obtained in these studies also were negative.

In 1960, Hepting and a group of Forest Service administrators and one non-Forest Service pathologist, Arthur Kelman, then on the faculty of North Carolina State University, made a trip to Idaho and Washington and visited the established test plots, including those areas in which Phytoactin had been applied by costly aerial sprays. In the course of this survey, it became clear that the claims for effectiveness of antibiotic sprays could not be substantiated. In some plots, evidence was found that a hyperparasite of the rust fungus (*Tuberculina maxima*) had become established in rust cankers and suppressed the growth of the rust fungus. Apparently, the effects of the hyperparasite had been overlooked and mistakenly attributed to the presumed effects of the antibiotic. On the basis of these findings and Hepting's firm insistence on the need for effective experimental controls as well as proper design and interpretation of results, a major costly federal

program was discontinued, saving many millions of dollars of public funds. Initially, Hepting was severely criticized for raising questions about this rust control program that was widely praised as an innovative control measure destined to save the highly valuable white pine stands of the western United States. However, Hepting had the courage to persevere until conclusive evidence was obtained to justify his conviction that data on control lacked validity.

In his administrative role, Hepting directed pioneering research on annosus root rot, soil fumigation in forest nurseries, and the role of ozone and other photochemical oxidants as causes of disease in forests (9, 11). His 1963 paper on climate and forest diseases is considered to be an authoritative treatise in the fields of both climatology and plant pathology (8).

He also developed the first computerized system for information retrieval in forestry (10). His 1971 text, *Diseases of Forest and Shade Trees in the United States*, provides the most comprehensive encyclopedia of knowledge on these topics (12). He wrote a definitive history of the failure of efforts to control chestnut blight (13) and similarly ineffective attempts to control the Dutch elm disease after these diseases were introduced into North America. In 1997, six years after retirement, Hepting co-authored an historical résumé of past achievements and future prospects in forest disease research (17). This publication also describes many of the impacts of Hepting's contributions on the advancement of forest pathology, nationally and internationally.

During the decade from 1966–1976, Hepting held the post of Visiting Professor of Forest Pathology and Forest Resources at North Carolina State University. On periodic visits to the campus during this period, he presented seminars and consulted with graduate students and faculty. In these sessions he provided encouragement, made critical assessments of research in progress, and served as a wise mentor and valuable source of knowledge from his broad background of experience. Hepting considered this phase of his career one of the most rewarding experiences of his professional life. Many graduate students considered their exposure to his wisdom and sharp wit as a highlight of their graduate education.

Together with Arthur Verrall, Hepting was cofounder of the Southwide Forest Disease Workshop, which became and still remains the outstanding forum for forest pathologists in this region (25). These workshops continue to provide an opportunity for research scientists and outreach workers from government, universities, and private industry as well as graduate students to share information on research in progress and to develop personal relationships that foster progress in cooperative research programs. Hepting's leadership in this and related activities resulted in strengthening forest disease research not only in the US Forest Service, but also in the universities in the southern United States. The Southwide Workshops indirectly had a role in the establishment and funding of industry-sponsored graduate fellowships in forest entomology and forest pathology. Hepting also had an influential role in the increased participation of forest pathologists in international forestry policy discussions and in the activities of the American Phytopathological Society, including the establishment of the subject matter committee on Forest Pathology.

He was an associate editor of *Phytopathology*, and for a number of years was a member of the Editorial Board of the *Annual Review of Phytopathology*. He also served on several committees of the National Academy of Sciences and edited the National Research Council text entitled *Principles of Plant Disease Control*.

Hepting's achievements in forest pathology were recognized by many honors and awards. In 1969, he became the first forester elected to the National Academy of Sciences. He also received the Superior Service Award of the US Department of Agriculture (1954) and the Barrington Moore Award for Outstanding Achievements in Forestry Research (1963). He was elected a Fellow of the Society of American Foresters (1965) and of the American Phytopathological Society (1966). He received the first Southern Forest Pathologist Achievement Award (1967), the US Department of Agriculture Merit Award for Achievement in Cost Reduction for development of an effective electronic literature retrieval system for forest pathology (1967), the Delta Airlines "Flying Colonel" Award for Service to Aviation (1972), the International Shade Tree Conference "Authors Citation Award" for his handbook on *Diseases of Forest and Shade Trees in the United States* (1974), and the Weyerhaeuser Award for Outstanding Historical Writing for the Forest History Society (1974).

In the course of his career, Hepting traveled extensively and completed research assignments in Europe, Puerto Rico, Haiti, and St. Croix. He also served as a consultant to the forest products industries of New Zealand and Australia.

Summary

Few investigators in the forest sciences were able in a lifetime to make as many major contributions as Hepting did on a very diverse range of complex problems. He had the ability to identify primary causal factors and rapidly gain the depth of understanding of disease situations that enabled him to devise practical approaches for management practices. Long before the concepts of integrated pest management became fashionable, Hepting emphasized the need to integrate disease hazard evaluations and knowledge of disease development processes into economically and biologically sound forest management systems. He also championed the need for basic research as a foundation for practical understanding and management of disease in forests. His role in the Timber Resources Review of 1953 also permanently changed our perception of the nature and magnitude of disease losses in forests (20).

Hepting was not only an effective leader in terms of his specific administrative assignments, but he was also an effective spokesperson for forest pathology and forestry in the United States. At the peak of his career, Hepting also became a recognized and influential international authority for forestry in the broad sense. In a reflective assessment of his career Hepting stated:

> It seems to me that there can be few walks of life in which a man following a specific occupation would lead a more varied existence than he would as a forest disease researcher. Within this seemingly restricted field, I have, over

a period of 20 years, been a rock breaker, a timber cruiser, a bacteriologist, an aircraft technologist, a lumberjack, a pathologist, a statistician, and an administrator. My territory has, from time to time, included much of our forest land from the Canadian border to the Gulf of Mexico and west to Texas and the Great Plains.

Hepting had a remarkable ability to stimulate and challenge co-workers and professional colleagues to do their best, to see the larger picture, to share their ideas with others, and to help "make forest pathology pay." He was also willing to speak frankly and critically when he thought the occasion demanded. In this connection, he insisted that his associates maintain the same high standards of scientific integrity and quality that he demanded in his own research. For these and other personal qualities, he earned the deep regard and high respect of his co-workers and members of his profession.

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LITERATURE CITED

1. Campbell WA, Copeland TL, Hepting GH. 1953. Managing shortleaf pine in littleleaf disease areas. *Southeast. For. Exp. Stn. Pap.* 25. 12 pp.
2. Hepting GH. 1935. Decay following fire in young Mississippi Delta hardwoods. *US Dep. Agric. Tech. Bull.* 494. 32 pp.
3. Hepting GH. 1939. A vascular wilt of the mimosa tree (*Albizzia julibrissin*). *US Dep. Agric. Cir.* 535. 10 pp.
4. Hepting GH. 1942. Reducing losses from tree diseases in eastern forests and farm woodlands. *US Dep. Agric. Farmers' Bull.* 1887. 21 pp.
5. Hepting GH. 1945. Reserve food storage in shortleaf pine in relation to little-leaf disease. *Phytopathology* 35:106–19
6. Hepting GH. 1947. Stimulation of oleoresin flow in pines by a fungus. *Science* 105:209
7. Hepting GH. 1955. The current status of oak wilt in the United States. *For. Sci.* 1:95–103
8. Hepting GH. 1963. Climate and forest diseases. *Annu. Rev. Phytopathol.* 1:31–50
9. Hepting GH. 1964. Damage to forests from air pollution. *J. For.* 62:630–34
10. Hepting GH. 1965. Codes to the INTREDIS register system for literature retrieval in forest pathology. *Southeast. For. Exp. Stn. Bull.* 61 pp.
11. Hepting GH. 1968. Diseases of forest and tree crops caused by air pollutants. *Phytopathology* 58:1098–101
12. Hepting GH. 1971. *Diseases of Forest and*

Shade Trees of the United States. US Dep. Agric. Handb. 386. 658 pp.
13. Hepting GH. 1974. Death of the American chestnut. *J. For. Hist.* 18:60–67
14. Hepting GH, Blaisdell DJ. 1936. A protective zone in red gum fire scars. *Phytopathology* 26:62–67
15. Hepting GH, Buchanan TS, Jackson LWR. 1945. Little-leaf disease of pine. *US Dep. Agric. Cir.* 716. 15 pp.
16. Hepting GH, Chapman AD. 1938. Losses from heart rot in two shortleaf and loblolly pine stands. *J. For.* 36:1193–201
17. Hepting GH, Cowling EB. 1977. Forest pathology: unique features and prospects. *Annu. Rev. Phytopathol.* 15:431–50
18. Hepting GH, Downs AA. 1944. Root and butt rot in planted white pine at Biltmore, North Carolina. *J. For.* 42:119–23
19. Hepting GH, Hedgcock GG. 1937. Decay in merchantable oak, yellow poplar, and basswood in the Appalachian region. *US Dep. Agric. Tech. Bull.* 570. 30 pp.
20. Hepting GH, Jemison M. 1958. *Forest Protection.* In *Timber Resources for America's Future*, US For. Serv. For. Res. Rep. 14, pp. 184–220. 713 pp.
21. Hepting GH, Roth ER. 1946. Pitch canker, a new disease of some southern pines. *J. For.* 44:742–44
22. Hepting GH, Roth ER, Luxford RF. 1942. The significance of the discolorations in aircraft veneers: yellow poplar. *US Dep. Agric. Bull.* 1375. 8 pp.
23. Hepting GH, Toole ER, Boyce JS Jr. 1952. Sexuality in the oak wilt fungus. *Phytopathology* 42:438–42
24. Jemison GM, Hepting GH. 1949. Timber stand improvement in the southern Appalachian region. *US Dep. Agric. Misc. Publ.* 693. 80 pp.
25. Powers HR, Miller T. *History of the Southwide Forest Disease Workshop 1959 to 1997.* Athens, GA: Southern For. Exp. Stn. 133 pp.
26. Roth ER, Hepting GH. 1943. Origin and development of oak stump sprouts as affecting their likelihood to decay. *J. For.* 41:27–36
27. Roth ER, Toole RE, Hepting GH. 1948. Nutritional aspects of the littleleaf disease of pine. *J. For.* 46:578–87
28. Toole ER, Hepting GH. 1949. Selection and propagation of *Albizzia* for resistance to *Fusarium* wilt. *Phytopathology* 39:63–70