Memorial to Eric Christopher Grimm 1951–2020

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Eric C. Grimm, an exemplary interdisciplinary Quaternary scientist, passed away unexpectedly on 15 November 2020. Eric was a skilled naturalist, geologist, botanist, palynologist, quantitative biologist, programmer, and database visionary. Born on 20 August 1951, in Cincinnati, Ohio, to Carl Albert "Al" and Jeanne Grimm, Eric soon moved with the family to Rapid City, South Dakota, where his father took a position as a mathematics professor at the South Dakota School of Mines (SDSM). This move was formative in Eric's professional and personal development. Frequent outings with his family, especially his father, into the adjacent Black Hills gave Eric a lifelong appreciation for nature and natural environments.

Eric C. Grimm at Homestake Mine, Black Hills, South Dakota. Photo credit: Angela Matthias.

After graduating from high school in Rapid City in 1969, Eric enrolled at the SDSM, intending to become a geologist. However, after two years, he transferred to South Dakota State University in Brookings, graduating in 1973 with highest honors in biology and with minors in mathematics and chemistry. Eric then enrolled at the University of Minnesota (UM) Twin Cities for graduate studies, receiving his MS with a major in ecology and minor in geology in 1975.

Supervised by Edward "Ed" Cushing, Eric's 1981 PhD dissertation at UM focused on the Big Woods, a large island of mesic deciduous forest surrounded by prairie and oak woodlands, west and south of the Twin Cities. Using nineteenth century land surveyor records, Eric found that elm, maple, and basswood dominated the Big Woods before agricultural land clearance (Grimm, 1984). His studies, however, of longer pollen stratigraphies from Big Woods lakes showed that the forests arose only 1–2 centuries ago. Eric's work suggested that onset of cool, wet conditions and a less vigorous fire regime in the 1600s and 1700s had contributed to replacement of oak savanna by mesic forest (Grimm, 1983). This was one of the earliest indications from paleoecology of the

dynamic interplay between climate variability, fire occurrence, and vegetation composition in the late Holocene—now a central focus of paleoecological research. This work established the prairie-forest ecotone in Minnesota as an important example of an ecological system with multiple stable states, maintained by fire-vegetation feedbacks and mediated by geographic position of firebreaks.

Eric's dissertation work at UM fit into a broader pattern of documenting Holocene vegetation dynamics on the Minnesota landscape under climate change. Eric's first years at UM overlapped with George Jacobson Jr., whose dissertation studies showed how white pine invaded oak savannas north of the Big Woods. John Almendinger similarly documented the advancement of jack pine into former prairie in northwestern Minnesota. His brother, Jim Almendinger, showed that water-table fluctuations were the cause of differential lake-level change in west-central Minnesota. Together, these dissertations from the Cushing lab showed the importance of hydroclimate, rather than just temperature, in driving vegetation changes.

While at the UM, Eric met Jane Allard; they were married in 1980 and became a lifelong team. Before his marriage, Eric shared a historic house on Grantham Street with graduate students and a sprinkling of seminarians. The atmosphere was scholarly but also filled with mirth and merriment, with Eric at the center of many activities. Many of the friendships and research collaborations forged there became lifelong.

Eric and Jane then skipped across the Atlantic, where he was a NATO postdoctoral fellow with John Birks at Cambridge University (1981–1982). He returned to the UM as a research associate with Ed Cushing (1983–1987). He was an integral member of research teams at the Limnological Research Center, where he worked with Herb Wright and a cadre of early-career paleoecologists who became leaders within the discipline. His research focused on the vegetation history and paleoecology of the northern Great Plains, an enduring passion throughout his career. Eventful coring trips during this interval have become legendary, largely through Eric's storytelling gifts. Eric also served as an instructor and lecturer in geology and geophysics (1985) and ecology and behavioral biology (1986), respectively.

In 1987, Eric joined an interdisciplinary team of scientists at the Quaternary Studies Center, Illinois State Museum (ISM) to work on an environmental impact statement for the State of Illinois for its bid to host the Superconducting Super Collider at Fermilab. Eric was hired as associate curator of botany in 1988 and became curator in 1996. In 1999, he became chair of the Department of Botany and director of the Landscape History Program. Eric's skills as a researcher and a manager led in 2013 to his advancement as director of science which involved the oversight of the departments of Anthropology, Botany, Geology, and Zoology. Eric retired from the museum in 2015, but he continued his research as an adjunct research associate at UM, until his death.

While at ISM, Eric's eclectic research ranged widely, embracing paleoecology, late Quaternary climate change, biogeography, and paleolimnology. In most of this research, Eric either led, or participated in, large interdisciplinary teams. Eric was a master of lake-sediment coring and of developing precisely and accurately dated lacustrine records of climate and vegetation. Eric's collaborative efforts yielded a number of benchmark records that inform our understanding of ecological and environmental change (Grimm, 2001; Clark et al., 2001, 2002; Brown et al., 2005; Nelson et al., 2006; Grimm et al., 2009, 2011; Gonzales and Grimm, 2009).

In a series of now-classic papers, Eric and others documented a 60,000-year record of vegetation history, limnology, and geochemistry of Lake Tulane in central Florida, producing the longest known continuous lacustrine record in the eastern United States (Grimm et al., 1993; Grimm et al., 2006; Donders et al., 2011; Jacobson et al., 2012; Novak et al., 2013). Meticulously dated sediment cores documented seven glacial-age vegetation phases dominated by pine pollen, interspersed with periods of primarily scrub oaks and/or prairie pollen. The pine phases persisted for up to several thousand years, and corresponded to the extended Dansgaard-Oeschger stadials terminated by Heinrich events. The intervening oak-prairie phases were coeval with Dansgaard-

Oeschger interstadials that initiated Bond Cycles. A pollen-climate inference model indicated that summer precipitation and mean November temperatures increased during the pine phases, consistent with a strong dipole in temperature between Florida and the North Atlantic region and summer persistence of the Atlantic Warm Pool (Donders et al., 2011).

Arguably Eric's most important scientific contributions came from his interest in data curation. As a curator of botany at ISM, Eric was in a peculiar position because he had no collections to curate: pollen slides deteriorate over time, and other botanical collections were overseen by another curator. Eric decided to create and curate digital archives of the pollen data that he saw disappearing as palynologists retired and passed away. Thus, the North American Pollen Database (NAPD) was conceived, soon followed by the European Pollen Database (EPD), with both inspiring databases from other regions, coalescing into the Global Pollen Database (GPD) (see Jacobson, G.L., Jr., 2021, A tribute to Eric C. Grimm (1951–2020): Palynology, https://doi.org/10.1080/01916122.2020.1870281). In developing the NAPD, Eric began with a research database compiled by Tom Webb. Eric was tenacious in encouraging palynologists to contribute original data, pioneering and firmly establishing the community norm that palynological data should be openly shared upon publication. In parallel, Russell W. Graham was independently creating the FAUNMAP database, focusing on late Quaternary fossil mammal sites from the literature. Because Eric and Russ were colleagues at ISM, they frequently discussed their databases and developed a parallel structure. In 2006 (Uhen et al., 2013) they decided to merge them into what eventually became the Neotoma Paleoecology Database (https://www.neotomadb.org/).

Eric and Russ, in collaboration with Jack Williams, Steve Jackson, and Allan Ashworth, were awarded a National Science Foundation grant to develop Neotoma as a single, unified data system deliberately designed to accommodate diverse paleobiological data. Experts from the Center for Environmental Informatics at the Pennsylvania State University (PSU) joined the Neotoma team in design and implementation. Today more than two dozen different constituent databases operate under Neotoma, which continues to grow. The name arose when Eric was returning to Illinois from a database meeting at PSU with Brandon Curry (Illinois State Geological Survey). Brandon observed that *Neotoma* is the scientific name for the North American packrat, which collects various items (plant parts, insects, bones, artifacts, etc.) and "curates" them in its nest. Eric appreciated the analogy, and the name stuck.

The ultimate purpose of Neotoma is to share data openly, fostering novel research at global scales and across multiple taxonomic groups. Neotoma is now recognized internationally as a top resource for paleoecological data (Williams, et al., 2018). Based on citation tracking by Publons, Neotoma now has an H-Factor of 80, with 772 citing publications that have themselves been cited over 27,700 times. Neotoma's data holdings and international community of data users, contributors, and stewards all continue to grow rapidly.

For Neotoma, Eric pioneered new tools for checking and curating data. TILIA, a software program originally designed by Eric for palynologists to tabulate data and generate pollen diagrams, was an outgrowth of Eric's CONISS program for stratigraphic clustering (Grimm, 1987), which was influenced by his experiences in the Cushing and Birks labs. Eric expanded and adapted TILIA as the data capture software for Neotoma, building self-governance capacity for each constituent database. Eric traveled the world hosting TILIA workshops, training the next generation of scientists to enter data directly into Neotoma. As a global ambassador for Neotoma, and an advocate for data sharing in the Quaternary sciences, he inspired an international cohort of early-career scientists.

As he traveled the globe, Eric's heart remained in his native Black Hills, a forested upland surrounded by high plains grasslands. He was fascinated by the mix of midwestern, boreal, and Rocky Mountain plants and animals. Over several decades, he tried valiantly to obtain datable Quaternary pollen records from the Black Hills, but nature and geology didn't oblige. Eventually he turned to vertebrate paleoecology, reasoning that Black Hills caves might contain relatively continuous late Quaternary fossil mammal records, which could be used with the Neotoma

database to find correlations between mammals and vegetation to reconstruct paleoenvironments.

Eric knew of a potentially fossiliferous cave because of an expedition that his parents had taken when he was a child. Although Eric was too young to accompany his parents, he said, "I was always intrigued by the large hemp rope and massive block and tackle that my parents used to enter the cave." With his father's assistance, he relocated the cave in 2000, and Eric eventually enticed Russ Graham to join him in excavations at the cave (Parker's Pit) and another cave nearby (Don's Gooseberry Pit). After ~14 years of work, Russ left the excavations in anticipation of retirement, but Eric continued with the assistance of two other vertebrate paleontologists, Jim Mead (The Mammoth Site, Hot Springs, South Dakota) and Chris Jass (Royal Alberta Museum). This work was still in progress when Eric passed away; Russ and others continue research into fossil mammals from these caves.

Eric received the Outstanding Service Award from the International Paleolimnology Association in 2012. He was awarded the American Quaternary Association's (AMQUA) Distinguished Career Award in 2016 for his extensive contributions to the advancement of Quaternary sciences. He was also a paleobiological councilor, president-elect, and president of AMQUA. Eric was a fellow of the American Association for the Advancement of Science (AAAS) and served as a member of the National Academy of Sciences/Natural Research Council U.S. National Committee for the International Union for Quaternary Research (INQUA). Eric is survived by his wife, Jane, daughter, Maria, her husband, Alex, and two younger brothers (David and Jeff) and their families. Eric will always be remembered for his inquisitive and encyclopedic mind, friendliness, openness, sense of humor, generosity, and willingness to help. He is missed by friends and colleagues all over the world. The Quaternary sciences are stronger and richer for his having shared his mind, his time, and above all, his friendship over many decades.

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