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OBITUARY

Eric C. Grimm 1951–2020

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The untimely death of Eric Grimm on 15th November 2020 in Jefferson, South Dakota is a much regretted loss to the global community of palynologists to which he contributed so much. Eric was a distinguished research palaeoecologist, a skilful and amusing companion in the field and one of the most widely known palynologists of his generation (Fig. 1). He is best remembered for his advocacy of open and shared international databases for fossil pollen and other palaeoecological data and almost single-handed creation, maintenance and patient, good-natured back-up service for the widely used Tilia platform that displays palaeoecological data.

Early career

Eric was born in Cincinnati, Ohio but grew up in Rapid City, South Dakota, where his father was an eminent mathematics professor at the South Dakota School of Mines & Technology. His father posed "Grimm's Conjecture" for consecutive composite integers and was a much appreciated teacher, who is also remembered for his avid appreciation of the Black Hills and his friendly smile. All these qualities and interests were strongly developed in Eric, with the addition of his generosity in sharing his knowledge and assistance on

Fig. 1 Eric Grimm visiting glacio-aeolian deposits at Lutterzand, the Netherlands in April 2017. Photo: Henry Hooghiemstra

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an international stage. Eric was awarded his PhD in 1981 at the University of Minnesota under the supervision of Ed Cushing, at a time when there were five independent palynological research groups at the university, including one led by the legendary Herb Wright at the Limnological Research Center (LRC). Margaret Davis and Ed Cushing had groups based in the Department of Ecology and Evolution, which suited Eric's biological interests. Ed Cushing is a gentle, generous scientist of extreme scientific rectitude and his numerical rigour is also a feature of Eric's subsequent work. Eric always loved numbers, and when Richard Bradshaw visited his laboratory in 1980, he was amused to see a very large figure written on the blackboard that was Eric's estimate of the number of pollen grains still uncounted in Minnesotan sediments. The number was revised downwards each week and was a typical Eric calculation. George Jacobson, also from Rapid City (their fathers were colleagues and friends), had helped with the counting, finishing his thesis in 1975. Eric's thesis topic on hypothesis-testing of drivers of Holocene dynamics in the Big Woods of southern Minnesota has become a classic. He combined pollen and historical land survey data to demonstrate the importance of fire and climate on the long-term invasion of prairie by forest communities (Grimm 1983, 1984).

Eric held a post-doc at the University of Cambridge directly after his PhD in 1981–1982, where he took part in the first European Union palaeoecological research project led by Bill Watts (Trinity College, Dublin) and John Birks (University of Cambridge). The exciting field trip along the western seaboard of Europe generated many stories and some useful data. Eric was mentor for two young Irish research assistants (Gina Hannon and Madeline McKeever) advising Gina while in the Cantabrian mountains on where to camp to minimise the risk of bear attack—a lesson she has never forgotten. While coring near Seville, their car was broken into (but note, not by a bear). Eric lost his passport and Bill Watts lost a manuscript he was editing from a Russian palaeoecological review volume that was never recovered (there were no digital backups in the 1980s). This project was the foundation for a long professional friendship between Eric and Bill Watts. Eric was a wonderful companion and expert in the field who helped with Bill Watts' numerous subsequent coring expeditions in Florida. Their collaboration culminated in the important papers that came from the Lake Tulane record where Eric, Bill, George Jacobson and others demonstrated striking correlations between *Pinus* and *Quercus* population fluctuations in Florida and the North Atlantic Heinrich events during the last glacial period (Grimm et al. 1993, 2006). Lake Tulane, with its 60,000 years timespan, still holds the record as the longest continuous lacustrine sediment sequence in the eastern US. Bill Watts regarded these publications with Eric as the academic high points of his own distinguished career.

After Cambridge, Eric returned to Minneapolis in 1982 and worked at the LRC on soft money, caught for a while in the dreaded 'post-doctoral trap', as were colleagues like Paul Glaser (University of Minnesota) and Steve Jackson (Brown University). Those were lean times for palaeoecologists in North America. During this period, Eric was encouraged by Herb Wright to begin exploring Holocene records of vegetation dynamics, drought episodes and fire on the northern Great Plains, comprising the states of North Dakota, South Dakota, most of Minnesota, Iowa, and Nebraska. These were topics and field areas that were to preoccupy much of his subsequent research career.

Illinois State Museum

In 1987, at the suggestion of Russell Graham, Chair of Geology, the Illinois State Museum (ISM) in Springfield hired Eric as a Research Associate in Botany to work with Russ and an interdisciplinary team of scientists in the ISM's Quaternary Studies Center on a contract in northern Illinois to investigate the potential location of a superconducting super collider. Eric was hired contractually to do palaeoecological research including coring and analysis of fossil pollen from Nelson Lake. ISM palynologist and Curator of Botany Jim King was also serving as Director of Sciences at the time and could not undertake the research. Jim left the ISM in 1988 to direct the Carnegie Museum of Natural History in Pittsburgh, which created the timely opening of a permanent position in Botany. The search committee wholeheartedly recommended Eric for the position, and ISM Director R. Bruce McMillan appointed him as Associate Curator of Botany. Eric happily left the world of soft money and launched his remarkable career at the ISM. He was promoted to Curator of Botany in 1996 and the Chair of Botany in 1999. Eric directed the ISM's internationally respected Landscape History Program (originally called the Quaternary Studies Center/Program) from 1999 until his retirement from the ISM. This interdisciplinary program, contributed to the understanding of long-term changes in climate, landforms, plant and animal communities, and human–environment interactions in Illinois, the Midwestern and Eastern United States, and the Great Plains. Eric worked closely with the ISM's geologists, palaeontologists, botanists, zoologists, and archaeologists (including zooarchaeologist Bonnie Styles), and outside researchers on numerous interdisciplinary projects. Because of his outstanding contributions, collegiality, and leadership, ISM Director Bonnie Styles appointed him as Director of Sciences in 2013.

Eric was committed to sharing his scientific research with the public. He worked closely with Bonnie Styles and played

a major role in the development of the ISM's natural history hall (Changes), which focuses on the forces of long-term environmental change and opened in 2004. His palaeoecological research is featured throughout the exhibition, but particularly in the portions dealing with environments and climate of the Ice Ages and the current interglacial period. He was a brilliant lecturer and excelled at describing complex topics in a friendly and understandable way. Eric's laboratory was a highpoint in behind-the-scenes tours of the ISM's Research and Collections Center. His public presentations on climate change always drew a crowd and were well received. He engaged the public in exploring changes in climate and vegetation and mentored numerous curators, students, and early-career scientists from across the world during his tenure at the ISM.

Eric was a prolific researcher while at the ISM and strengthened the international recognition and respect for his studies of fossil pollen (palynology) and long-term changes in vegetation and climate. His research expeditions were legendary and often involved freezing while coring through ice-covered lakes to collect sediment cores from their bottoms, so he could extract and analyse the fossil pollen. He also cored lakes in Illinois and surrounding regions from a platform supported over two canoes. His Illinois research documented the decline of spruce at the end of the most recent Ice Age, the establishment of mesic deciduous forest in the early Holocene, and the Holocene expansion of tallgrass prairie in Illinois.

This period was the most academically productive of Eric's career. He participated in collaborative research projects supported by numerous NSF grants that documented the postglacial history of the Northern Great Plains with Herb Wright (University of Minnesota) and Cathy Barnosky (Carnegie Museum of Natural History), rates of long-term climate and vegetation changes in North America and Europe with George Jacobson (University of Maine), long records of palaeoclimate from Florida with George Jacobson and Bill Watts (Trinity College, Dublin), prehistoric biomass burning at local to regional scales in Eastern North America with James Clark (Duke University), sub-decadal reconstruction of drought patterns for North America's arid interior with Sherry Fritz (Lehigh University) and James Clark, Holocene drought cycles and impacts on the Northern Great Plains with James Clark and James Donovan (West Virginia University), a late glacial model system for studying fine-scale vegetational responses to abrupt climate change with Jack Williams (University of Wisconsin, Madison) and Brandon Curry (Illinois State Geological Survey), and floral and faunal community responses to Late-Quaternary climate change with Jack Williams, Russ Graham (Pennsylvania State University), and Stephen Jackson (University of Wyoming). See below for further description of these research projects.

During his tenure at the Museum, Eric developed the North American Pollen Database and served as an advisor to the Global Pollen Database. At the same time, ISM palaeontologist Russ Graham developed FAUNMAP, a database documenting late Quaternary distributions of mammal species in the United States based on archaeological and palaeontological data. They began a collaboration that eventually led to the development of the Neotoma Paleoecology Database and research community (Graham and Grimm 1990; Williams et al. 2018), which is arguably the most significant scientific legacy of Eric's career. The history and importance of these database projects are further explored below.

Tilia

The Tilia platform for the storage, analysis and display of palaeoecological data is one of Eric's greatest and most widely appreciated legacies. It was initially developed during the early 1980s at the time when pollen diagrams were mostly drawn by hand. With subsequent increasing access to computers, several programmes were developed for the purpose of making a pollen diagram and among these, Tilia became the most widely used. Eric designed Tilia to consist of two parts: a spreadsheet and a graphics component, TiliaGraph. His pollen data from Wolsfeld Lake is probably the one pollen data set that was most widely distributed on individual computers in the DOS era, as it was shipped as an example dataset with the DOS version of Tilia. The original DOS version had several additional forms to capture all the metadata. It included a dictionary where taxa names had to be defined. This dictionary could be saved and reused when entering data for another site, minimising the occurrence of misspellings, although these still occurred. Eric's Tilia also included a very didactic way of constructing pollen sums. Eric was well versed in the history of the development of palynology and the Windows version of Tilia has a default setting making sums that always include the taxon to be expressed based on that sum to avoid percentage values above 100%. This is a practice not universally adopted and originates from the schools of thought from which Eric had emerged. The graphical component also retains several features developed in the early days of pollen, including the Troels-Smith (1955) system for visualisation of types of soft sediment. Tilia also comprises the analytical tool CONISS for making stratigraphically constrained cluster analysis and has become the most widely used software for this purpose, even when other parts of the Tilia package are not used. Eric's generosity and personal assistance in supporting users of Tilia, CONISS and TiliaGraph over many years was an early signifier of Eric's visionary commitment to open software and open data, which continued forward in Eric's leadership in the development of palaeoecological

databases and associated new research (Grimm 1987; Grimm et al. 2013).

Open-access databases

Eric contributed to science in many ways, but his contribution of making data available and building both the community support and fundamental database architecture for open access databases is outstanding and epitomises his selfless dedication to Quaternary science. He was a pioneer in promoting open data, which he did by developing the databases that made this possible, but also in discussions with colleagues, where he would always stress that all the data he produced are freely available.

Soon after his arrival at ISM, he visited Tom Webb at Brown University and negotiated the transfer of the pollen database that Tom and others had developed during the Cooperative Holocene Mapping Project, to a more stable base at a major museum. Eric argued persuasively that a museum could manage the long-term curation of data as effectively as old bones or artefacts and that, for the palynologists, the curation of digital data was as important, or even more so than curation of the pollen preparations and slides. Tom Webb eventually agreed to release the North American pollen data that he had worked so hard to bring together. As his first postdoc, Richard Bradshaw had overheard Tom's long phone calls to American palynologists convincing them of the scientific benefits of large, integrated datasets. This historic negotiation resulted in the establishment of the North American Pollen Database (NAPD) at ISM. Eric thought big and already had a vision for a Global Pollen Database (GPD). Eric and George Jacobson skilfully persuaded a diverse crew of leading European palynologists to establish a European Pollen Database at a 1989 meeting at Frostavallen, Sweden. European palynologists proved even more resistant than Americans to the idea of contributing their hard-counted pollen data to a central site. Several argued for regional databases with strict quality criteria, barring data that did not meet the standards, but Eric's broader vision has proved to be the winner, with the now accepted paradigm that the criteria for acceptable data varies by data user and by research question, and so data users rather than database managers should make the ultimate decision about the choice of appropriate data standards. It has helped that digital memory is now far cheaper than it was back in the last century.

In the 1990s, Eric helped make this vision global, as he was subsequently involved in several pollen database initiatives in Africa, China, the Indo-Pacific region, Japan, Latin America and Siberia and the ultimate launching of the GPD, which was housed by NOAA's World Data Center for Paleoclimatology. Together with his Tilia platform for handling, analysis and display of data, he became a familiar figure to palynologists worldwide. In 1999 the first GPD meeting was held in Colorado, and Richard Bradshaw hosted a second GPD meeting (2001) in a medieval Danish Castle, where Eric led the discussions and gave a uniquely learned lecture on the critical topic of taxonomic harmonisation in pollen databases. Eric developed user-friendly data entry and analytical software using his programming skills and made them freely available to the scientific community.

In 2006, Eric teamed up with Russ Graham and others to launch the Neotoma Paleoecology Database, with the vision of creating a unified database structure that supported all palaeoecological data types, rather than separate databases for pollen (GPD), vertebrates (FAUNMAP), ostracods (NANODe) and other taxa. Scientifically, this unified framework enables new questions into the study of community dynamics across many taxonomic groups during periods of environmental change. The creation of one unified database that could support multiple types of palaeoecological data also helps reduce costs, helping solve a problem of sustainability that has plagued many smaller databases. Eric's design of Neotoma was brilliant, at several levels. First, he created a generic and flexible data model that was able to store any kind of palaeoecological observation from any sedimentary context, regardless of whether this was e.g. a lake core, an archaeological dig, or a vertebrate assemblage from a cave. This data model drew upon lessons learned when designing the GPD, NAPD, EPD, and other pollen databases and Eric's remarkable breadth as a Quaternary scientist. He was also influenced by experience from his annual expeditions to the Black Hills to carry out vertebrate excavations at a cave with his close colleague Russ Graham. Second, Eric created a clever and unique design that combined a centralised database (all Neotoma data are stored in one structured relational database) with a distributed structure for scientific governance and community data curation, in which data are uploaded and curated by networks of Data Stewards, organized into Constituent Databases. Neotoma's centralized database keeps costs down by just having one database to support rather than several and its structure supports a whole ecosystem of software such as Neotoma Explorer, the R package (Goring et al. 2015), and Tilia itself. Along the way, Eric further modified Tilia to be able to upload and download datasets to and from Neotoma, with a number of tools for Stewards to vet their data prior to upload. The distributed governance allows experts to be in charge of the data they know best, with palynologists uploading and curating pollen data, and other specialists uploading and curating their own types of data (Williams et al. 2018). This model for community curation has allowed Neotoma to steadily build and grow over the last decade and become widely recognised as one of the preeminent international data resources for open, high-quality

palaeoecological data. It is now a foundational resource for broad-scale global change research. Once again, by designing Neotoma and its model for community data curation, Eric was 10 years ahead of his time.

Research contribution

His own scientific investigations have made a strong impact on the scientific community and his earlier works are still read and cited today. Among the many topics that Eric's research was concerned with, the following ones stand out: forest prairie boundary, rate of change, Lake Tulane, Kettle Lake and revision of radiocarbon dates for North America.

His doctoral work on the forest prairie boundary of Southern Minnesota resulted in two milestone publications (Grimm 1983, 1984) documenting the past and stimulating arguments more than 40 years after their publication. Eric's doctoral work was a pioneering, and often underappreciated, forerunner to the current ecological literature about alternate stable states, by arguing that the mosaic of prairie, woodland, and mesic deciduous forests in the Big Woods did not represent a shifting mosaic of transient successional stages, as earlier ecologists had posited (Loucks 1970; Heinselman 1973), but rather that these different vegetation types and their mosaics were persistent and stable over centuries to millennia. His 1983 paper used two carefully selected and dated lake sediment cores to test an ecological hypothesis, which depended on the ability to date accurately the events in the two cores. To meet this challenge Eric considered a minor reservoir effect on the age of the radiocarbon dates he obtained and converted the ages to the calendar time scale which was uncommon at the time of the publication. Moreover, he argued for the use of deposition time (years/cm) rather than sedimentation rate (cm/year) which has now become the basis for Bayesian age modelling. He maintained this interest in building accurate chronologies and promoted Bayesian age modelling also through facilities in his Tilia program. In the second publication (Grimm 1984) he used historical data documenting the forest composition in Minnesota in the mid-19th century to reconstruct the spatial distribution of the forest prairie ecotone. Based on the long term perspective and the spatial changes in composition, Eric could show the importance of fire shaping the vegetation, contributing to the later emerging studies on long term fire ecology, although he did not have independent evidence of changes in fire frequency such as charcoal.

Eric also pioneered with George Jacobson the calculation of the rate of past ecosystem change from palynological time series, which has become a standard procedure for individual sites (e.g. Lotter et al. 1992) and continents. Initially Eric used the distance between sample scores extracted from an ordination to assess the magnitude of change for a site in the forest and prairie ecotone of central Minnesota (Jacobson and Grimm 1986). Later he made use of the chord distance to evaluate the rate of vegetation change during the deglaciation of eastern North America (Jacobson et al. 1987). Jacobson (2020) describes that the idea for similar analyses of European pollen data was one of the motors leading to the establishment of the European Pollen Database. A paper describing the method with an application to the past 18,000 years in eastern North America followed later (Grimm and Jacobson 1992).

Eric enjoyed fieldwork and organized many coring campaigns producing hundreds of metres of sediment cores. Two of the many sites that Eric investigated yielded spectacular results that will stand the test of time. These are Lake Tulane in Florida and Kettle Lake in North Dakota. Lake Tulane represents one of the few sites available in North America to yield a continuous terrestrial pollen record for the last 60,000 years. Peaks in *Pinus* pollen could be linked to Heinrich events telling a story of a strong antiphase relationship in temperature between Florida and the North Atlantic region (Grimm et al. 1993). This work continues to be a cornerstone of our understanding of millennial-scale variability in the Atlantic, for it suggests that when the North Atlantic cooled due to Heinrich meltwater pulses, Florida and the south-eastern US either showed no cooling or even warmed slightly, perhaps due to shifts in ocean current strength or jet stream position (Fastovich et al. 2020). Eric knew since his PhD work that a rigorous chronology is the prerequisite for sound interpretations and thus radiocarbon dating and building chronologies is one topic given much emphasis in his work. He demonstrated that some early accounts of the timing of vegetation change in North America were flawed by chronologies based on conventional dates subject to the hard water effect (Grimm et al. 2009). He contributed to revising the chronologies in the North American Pollen Database (Blois et al. 2011), building the foundation for continental scale analysis of past vegetation change. Eric was unsatisfied with the dating of the original Lake Tulane core using conventional decay-count dates of large bulk-sediment sections. When radiocarbon dating by AMS became available, Eric collected a new set of cores and developed a more rigorous age model based on 55 AMS radiocarbon dates, including dates on macrofossils wherever available (Grimm et al. 2006). Developing a rigorous chronology also became a story for the cores from Kettle Lake. Using 53 AMS dates, mostly from herbaceous charcoal particles, Eric developed a well-constrained age model for the last 13,000 years (Grimm 2011). Kettle Lake is a closed basin situated in the northern Great Plains and water level fluctuations resulting in changes in sediment chemistry as well as the surrounding herbaceous vegetation react to decadal

scale climate variations that were investigated in these cores based on many proxy types and supported by the chronology (Grimm et al. 2011). The analytical detail of pollen, charcoal and minerals is impressive, but the discussion is a masterpiece, with several earlier hypotheses from the literature, re-evaluated and detailed new insights gained into major climate events and mid-Holocene wet-dry cycles of the northern Great Plains. The arguments for the *Selaginella densa* records responding to bison and subsequently cattle grazing are original and convincing (Grimm 2011).

Wider service to the community

Eric's generosity in mentoring, his commitment to scientific excellence, and commitment to open data, all made him a beloved role model for an international community of young scientists. As a curator, Eric had no students of his own, although he acted as a co-advisor for some students such as Leila Gonzalez and Buzz Nanavati. But Eric loved working with younger scientists and was extraordinarily generous with his time and advice, whether it was technical support for Tilia or how best to core a lake. Whatever Eric did, he did well, and his ability to combine both big vision and attention to detail is one of his great hallmarks as a scientist. His commitment is further reflected in numerous workshops Eric organized around the world. With the increasing global extent and interest for the use of datasets in Neotoma, Eric covered all continents and his encouraging, supportive engagement with young researchers has helped palaeoecology flourish and left a considerable legacy.

Eric also rendered service to the academic community and to early career researchers by joining the editorial board of Vegetation History and Archaeobotany as Associate Editor in 2006. Up until then, the journal had achieved little success in reaching American scientists, despite several specific efforts and initiatives. Eric promoted the journal among his colleagues and recommended additional Associate Editors who have subsequently enhanced its international profile. He has left a valuable legacy that will continue to develop. A particularly valuable legacy is the influence Eric has had with early stage researchers. There was no person at any conference or workshop who was more accessible than Eric. Any question or idea would be welcomed with a warming smile, twinkling eyes and thoughtful answers. His unlimited generosity in sharing knowledge and helping with any query, made it feel that a moment with Eric would be a moment to learn and understand more. For Eric, the world was filled with fun and interesting facts, and he would be thrilled with excitement uncovering unknowns and solving questions. This excitement always generated a welcoming warm atmosphere for early stage researchers. There are numerous cases where Eric, as a co-author or reviewer, would improve the English for those being challenged to write in a foreign language. Knowing the importance of publishing and recognition from the scientific community, Eric would frequently invite early career researchers to be part of ongoing publications and projects. For Eric, everyone had valuable insights to share. Consequently, there is now a global community of early stage researchers who all carry his sparks of enthusiasm and knowledge. His legacy lives on in the lives of many young researchers around the world who continue to be grateful for everything Eric shared and represented.

The later years

In 2015, Eric resigned and took early retirement from ISM together with most of the senior staff in protest to the Illinois Governor's closure of the 138 year-old institution to the public, despite opposition to the Governor's action by the Illinois Legislature and a large outcry from the public, media, and professional communities across the U.S. and the world. Eric was devastated, telling Science magazine "you watch the whole thing you helped build be brought down basically because of politics." Eric moved his research materials back to his alma mater in Minneapolis and continued his research and the development of the Neotoma database with another NSF grant and an appointment as an Adjunct Research Professor and member of the Graduate Faculty at the University of Minnesota. He worked from his home office in Jefferson, South Dakota where he lived with his wife Jane Allard. It was an undeserved, stressful and disappointing career development, but Eric continued unabated his research and his selfless service to the palynological and broader palaeoecological research community. During this time, he worked with Buzz Nanavati on a high-resolution fossil pollen and charcoal record from the Ozarks in Missouri (Nanavati and Grimm 2019). He and Jane returned to Lake Tulane in January 2020, shortly before pandemic lockdown, for a new set of cores, to test hypotheses about megafaunal-vegetation interactions during millennial-scale climate variations (Fig. 2). During this time, he helped train another generation of young scientists (Angie Perrotti, David Fastovich, Claire Rubbelke) in the right way to core a lake, passing on lessons learned and stories from his campaigns with Bill Watts, Herb Wright, George Jacobson, and many others. He was deeply involved in the on-going development of Neotoma, acting simultaneously as Lead Data Steward, lead developer of Tilia, and lead developer of the Neotoma data model. He met weekly with the rest of the Neotoma team and was in active conversations by email and Slack until almost literally his last moment. He spoke at INQUA, Dublin 2019 where his talk titled "Pollen databases: from von Post to Neotoma" was given to a fully packed lecture

Fig. 2 Eric and colleagues coring at Lake Tulane, Florida in January 2020. Watercolour by Jane Allard

theatre with a large crowd outside the doors straining to hear what they could. Eric was one of the best-known speakers at this major international meeting of the Quaternary Sciences. Eric and Jane were also planning together a retirement home in the Black Hills, which Eric loved, and where he had bought land adjacent to his two brothers. One of the great sadnesses of Eric's premature passing is that he never got to spend his golden years in the Black Hills, which he had explored as an Eagle Scout.

In the current discussion of how to evaluate scientific contribution by other means than bibliographic measures of productivity, Eric set a fine example. As a museum employee, Eric had numerous tasks besides that of publishing scientific papers. He contributed significantly to exhibitions and public programs and guided a team of interdisciplinary scientists, including palaeoecologists, geologists, botanists, zoologists, and archaeologists. His published output in terms of numbers appears modest compared with many of his peers, but his publications are usually long, rich in data, carefully argued and become important, well-cited contributions. His legacy based on the development of open databases, traveling the world promoting them and educating researchers of all ages in how to make use of them, cannot be overvalued. He was a pioneer and ambassador for open data and data sharing before these topics became important in academia. Eric Grimm's selfless personality, modesty and special sense of fun made him one of a kind. He reached across the generations of palynologists and other paleoecologists contributing to a strong sense of an international community. He has left a tremendous legacy in the subject area, both amongst his colleagues and trainees and through his software, publications, advocacy of databases and training sessions. His memory will be treasured by many for years to come.

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