

Women in conservation science making a difference

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Abstract. Conservation science has a long history of providing the evidence-base that underpins management of diverse and unique biota and landscapes. This special issue brings together the stories of a range of women in conservation science to showcase the great work being done to develop and improve our knowledge and understanding of Australian plants, animals and ecosystems, across a range of disciplines and sectors. We focus on Australia in recognition of recent commitments by Australian institutions to achieve gender parity in Australian science, while acknowledging the achievements of women in conservation science globally. In this overview we highlight several exemplary women who have paved the way for those of us who have come after them, and present a brief snapshot of the careers of these women to acknowledge their contributions to the development of conservation science, and its associated disciplines. We also distil some common themes that have been identified by the women in the articles featured in this special issue, particularly passion and enthusiasm for the natural environment; multiple pathways that women have taken; satisfaction derived from working collaboratively across disciplines and with a variety of scientists, policy, managers and practitioners; and seeking to embrace diversity. A striking point from many of the stories, that we hope is changing now, is that many of the women had few female role models, yet the stories highlight their resilience and determination and their desire to inspire other young women to take up the challenge of a career in conservation science.

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Introduction

Conservation science is a strong discipline in Australian science, with a long history of providing the evidence-base that underpins management of Australia's diverse and unique biota and landscapes. It is an interdisciplinary science, drawing on a range of disciplines to provide a scientific basis for management. Australia's conservation scientists have strong connections to conservation management, and managers look to science for knowledge and understanding.

In this special issue we highlight a range of women working in conservation science in Australia to showcase the great work being done to develop and improve our knowledge and understanding of Australian plants, animals and ecosystems, and tell the stories of a handful of the many women who have made significant careers in conservation science. Their stories present engaging views of the fantastic opportunities we have in our careers as scientists, as well as the challenges associated with working as a conservation scientist. These women represent a variety of disciplines from marine to wetland to terrestrial, plant

to animal to ecosystem science, from taxonomy and genetics to climate change and decision theory. Their careers also span academia, government, CSIRO, museums and herbaria, and the non-government sector.

This publication is timely as Australian academic institutions have recently committed to addressing the gender inequality that is present in science, technology, engineering, mathematics and medicine (STEMM) fields in Australia and worldwide. Through the Science in Australia Gender Equity (SAGE) initiative, a partnership between the Australian Academy of Science and the Australian Academy of Technology and Engineering, around 40 institutions have signed up to conduct an in-depth self-assessment of their institution's structures, systems and culture to identify gaps in and barriers to gender equity in STEMM (<http://www.sciencegenderequity.org.au>). To be awarded Bronze status these institutions must demonstrate that they have developed a robust and measurable action plan to address identified gaps and barriers to improve gender equity. This initiative, and others like it, should help identify and redress

some of the barriers that to date have prevented some talented women entering conservation science.

By bringing together a smorgasbord of inspiring stories from a cross-section of women in conservation in Australia today, we hope that we will excite and motivate young women starting their careers in science, as well as encourage senior school students looking for options and career opportunities in science. Our focus is Australian given the contemporary SAGE initiative, but we acknowledge that the Australian perspective is a subset of the outstanding achievements of women in conservation science globally. The stories provide affirmation and inspiration to all who work in conservation science, and we hope they will be inspiring for our male colleagues also. Many of the women did identify particular men who made a difference to their path, providing advice, assistance and opportunities for the women around them to achieve their goals. We applaud these men for their vision and support in championing their female colleagues, particularly as this was before the current focus on gender equity in science.

Standing on their shoulders

As women in conservation science we come from a proud lineage of strong women (Fig. 1) who have made incredible contributions, sometimes under difficult circumstances, to our understanding of the Australian biota over many years. These women have paved the way for those of us who have come after them, and provided inspiration to all of us. They have undoubtedly faced many challenges throughout their careers, yet their contributions shine out as they have forged a path forwards for us to follow. We present a brief snapshot of the careers of some of these women to acknowledge their contributions to the development of conservation science, and its associated disciplines in Australia. While these women may not have been recognised explicitly as conservation scientists, their research has provided a basis for the development of conservation science as a discipline in Australia.

Nancy Burbidge

Dr Nancy Burbidge AM (1912–1977) was an exemplary early botanical scientist. She is remembered for her pioneering work at the Australian National Herbarium and for her capacity for botanical art, as well as science communication with the broader community. Nancy was born in England but grew up in Western Australia and gained BSc, MSc and DSc degrees in botany from The University of Western Australia in 1937, 1945 and 1961 respectively. She spent time at Royal Botanic Gardens Kew working on Australian grasses, before moving to CSIRO where she played a pivotal role providing botanical information and managing a herbarium collection that now forms the basis of the Australian National Herbarium. Nancy is recognised for her botanical expertise, her phytogeographical understanding of Australia, and her initiation of the Flora of Australia. During her career at CSIRO she developed her knowledge and expertise across a wide range of botanical science, particularly in the taxonomy of *Nicotiana*, *Sesbania* and *Helichrysum* groups and the Australian grasses, publishing three volumes on Australian grasses, the *Dictionary of Australian Plant Genera*, and a pioneering analysis of the phytogeography of the Australian region,

as well as many scientific papers. Nancy was the first director and avid supporter of the Flora of Australia project that continues to this day, after previously completing, with Max Grey, a Flora of the Australian Capital Territory. She contributed to science extension through membership of the Systematic Botany Committee of the Australian and New Zealand Association for the Advancement of Science and was an initiator of the Australian Systematic Botany Society. She had a strong commitment to conservation and was a founding member of the ACT National Parks Association. Nancy was an advocate for the advancement of women in science and other professions, being active in the Australian Federation of University Women and President from 1957–1958. Nancy was made a Member of the Order of Australia in 1976 for her contributions to botany. Her contribution to systematic botany and conservation is commemorated through the Nancy T. Burbidge Medal that is awarded annually by the Australian Systematic Botany Society and the Nancy T. Burbidge Memorial Amphitheatre at the Australian National Botanic Gardens, Canberra. Nancy was an inspiration to many women and men in botanical science in Australia, and her legacy lives on through her nephew Dr Andrew Burbidge who made a significant contribution to animal science and conservation, and her great niece, Dr Fran Stanley, who has a leadership role in the Western Australian government agency responsible for conservation.

Isobel Bennett

Dr Isobel Bennett AO (1909–2008) was an extraordinary woman working in marine science in its early years in Australia. She commenced this work through a chance encounter with Professor William Dakin from the University of Sydney and collaborated with him for many years. Although Isobel had no formal tertiary training her expertise in marine biology was recognised when she was awarded an Honorary MSc by the University of Sydney in 1962 and an Honorary DSc from the University of New South Wales in 1995. Through her meticulous observation and scientific mind, Isobel became an expert on intertidal zones, as well as an authority on plankton and coral. She wrote numerous books that are so popular they have been revised and updated several times. Isobel's work on the corals of the Great Barrier Reef was instrumental in the recognition of the Reef as a UNESCO World Heritage Site. Isobel also undertook research on Macquarie Island, being one of the first women allowed to visit through the 1959 Australian National Antarctic Research Expedition, and wrote a book 'Shores of Macquarie Island'. In 1982 she was awarded the ANZAAS Mueller Medal, and has received three Whitely Awards from the Royal Zoological Society of NSW for her books. In 1984 Isobel was made an Officer of the Order of Australia for her services to marine biology.

Hope Black (nee MacPherson)

Jessica Hope Black (1919–2018) was a recognised expert in marine biology. She studied part-time and received her BSc from the University of Melbourne in 1946. Hope developed her expertise in marine biology through numerous biological surveys, mainly in Victoria, and became an expert in molluscs producing a book on the molluscs of Victoria. She was the first female curator at the National Museum of Victoria being



Fig. 1. We stand on the shoulders of great women who paved the way for female engagement in conservation science in Australia. Highlighted in this paper (from left to right, top to bottom): Nancy Burbidge, Isobel Bennett, Hope Black (nee MacPherson), Pauline Ladiges, Judy West, Jenny Marshall Graves, Marilyn Renfree, Margaret Friedel and Helene Marsh. Photographs supplied, used with permission.

appointed as Curator of Molluscs in 1946. Hope was one of the first women to undertake research on Macquarie Island through the 1959 Australian National Antarctic Research Expedition. Hope was an early exemplar of application of science in

environmental management, participating in surveys of the Snowy River Gorge and leading surveys of Port Phillip Bay that are used today as baselines for monitoring change. Hope was also an early advocate of including the community in science

and established volunteer programs to assist with research on museum collections. Unfortunately Hope had to leave the Museum of Victoria in 1965 when she married, but she continued to inspire future generations through working as a science teacher. Hope's contribution to marine science was recognised when she was inducted into the Victorian Honour Roll of Women in 2012.

Pauline Ladiges

Professor Pauline Ladiges FAA AO has been a leader in the Australian botanical community in the fields of taxonomy, ecology and biogeography for many decades. Pauline gained her BSc in 1971, MSc in 1972 and PhD in 1976 all from the University of Melbourne. She began her career as a plant ecologist but in the early 1980s she transitioned into plant systematics where she pioneered studies in phylogenetics and biogeography of Australian plants. She is most well known for her work on eucalypts using morphological and molecular approaches to discover the evolutionary relationships of these important Australian genera. Pauline was Head of the School of Botany at the University of Melbourne from 1992 to 2010 and remains a professorial fellow following her retirement from that role. Pauline has been dedicated to educating the next generation of Australian scientists, and has produced several education text books. Pauline is active in community service, including serving on boards or advisory committees of the Australian Biological Resources Study, Royal Botanic Gardens of Victoria, Royal Society of Victoria, Dahl Trust, and Hermon Slade Foundation. From 2014 to 2018 she took on the role of Secretary for Education and Public Awareness for the Australian Academy of Science. In 2001 Pauline was awarded the Centenary Medal for service to Australian society and science, in 2005 the Royal Society of Victoria Research Medal, and in 2011 the Nancy T. Burbidge Medal from the Australasian Systematics Society. She was elected a Fellow of the Australian Academy of Science in 2002. In 2009 she was made an Officer of the Order of Australia for advancement of botanical science and research, and to the conservation of Australian flora and fauna.

Judy West

Dr Judy West AO has been an inspiration to many women in botany over many years. Judy gained a BSc (Hons) degree in 1972 from the University of Sydney and a PhD degree from the University of Adelaide in 1981 for a taxonomic revision of *Dodonaea* in Australia. She then moved to CSIRO and the Australian National Herbarium where she undertook a range of taxonomic and systematics research. She was the Australian Botanical Liaison Officer at Royal Botanic Gardens Kew in 1987–1988, a role that included duties related to Australia's bicentenary celebrations. Judy followed in Nancy Burbidge's footsteps as leader of the Australian Flora Resources and Management program, and was Director of the Australian National Herbarium from 1989 and Director of the Centre for Plant Biodiversity Research when it was formed through a partnership between CSIRO and the Australian National Botanic Gardens. She was instrumental in establishing Australia's Virtual Herbarium, enabling the information captured in herbarium collections to be made readily available to the

community. More recently she became Executive Director of the Australian National Botanic Gardens and Head of Parks and Biodiversity Science within the Commonwealth Department of the Environment, where she has oversight of science activities in Commonwealth reserves and facilitates research partnerships of high value to management of the parks. Throughout her career Judy has been incredibly active in a wide range of organisations, associations and committees, with a passion for promoting the Australian flora and increasing our knowledge and understanding of biodiversity. In 2001 Judy was awarded the Nancy T. Burbidge Medal, and in 2003 she was awarded the Officer of the Order of Australia for her services to Australian botany.

Jenny Marshall Graves

Professor Jenny Marshall Graves FAA AO is a leader in animal science, particularly in the areas of mammalian chromosomes and comparative gene structure and regulation. Jenny gained her BSc (Hons) and MSc degrees in marsupial cytogenetics from the University of Adelaide in 1964 and 1967, before a Fullbright Travel Grant took her to the University of California, Berkeley, where she obtained a PhD in 1971. Jenny returned to Australia to a position at La Trobe University where she pioneered investigations in mammalian sex-determining genes and genome mapping. She established a vibrant laboratory focused on pursuit of scientific ideas while enjoying science, and was an inspiration to the PhD students and post-doctoral fellows who worked with her as she led internationally significant advances in understanding sex-chromosome structure and function using marsupials in comparisons with placental mammals. In 2001 Jenny moved to the Australian National University as Head of the Comparative Genomics Research Unit and Director of the ARC Centre for Excellence in Kangaroo Genomics. Jenny demonstrated how it was possible to pursue scientific excellence and produce an impressive publication record while maintaining a family life. Jenny remains active in research as Distinguished Professor at La Trobe University, as well as through honorary positions at Australian National University, University of Canberra and University of Melbourne. She is a champion of many international initiatives, including as a member of the Steering Committee of the Genome 10K program that seeks to sequence the genomes of all vertebrate genera. Jenny worked to advance the careers of women in science at the local, national and international levels, and was the 2006 laureate of L'Oréal-UNESCO international awards for women in science. Jenny became a Fellow of the Australian Academy of Science in 1999 and served on the Academy executive, first as Foreign Secretary, then as Secretary for Education and Public Affairs. She was awarded the Centenary Medal in 2001, the Macfarlane Burnet Medal in 2006 and the Prime Minister's Prize for Science in 2017. She was awarded an Officer of the Order of Australia in 2010 for pioneering investigations of the genetics of sex.

Marilyn Renfree

Professor Marilyn Renfree FAA AO is a leading reproductive and developmental biologist with expertise on Australian marsupials, their reproduction and development. Marilyn obtained a BSc (Hons) in 1968, a PhD in 1972 and a DSc in 1988, all from the Australian National University. She was a post-doctoral

fellow in Tennessee and then Edinburgh before returning to Australia to work at Murdoch University and then Monash University. Since 1991, she was the Ian Potter Chair of Zoology and since 2003, University Laureate Professor at the University of Melbourne. Marilyn pioneered the use of marsupials as models for biomedical research in reproductive and developmental biology, and this fundamental research has enabled her to also apply the knowledge to conservation issues, such as designing contraceptives for kangaroos and koalas that are now used by Parks Victoria to control koala populations in restricted habitats. She also worked on the platypus and the echidna, and has recently taken the opportunity to study the reproduction and development of echidnas with Queensland colleagues, and monitor their growth after they hatch from the egg, a remarkable process for a mammal. She is passionate about educating the Australian and international public about the uniqueness of our Australian marsupials, to improve public understanding of their value in terms of tourism and biodiversity conservation, and to ensure that these iconic species are valued and protected for future generations. Marilyn's contribution has been recognised through numerous national and international awards and Fellowships, including NHMRC and Federation Fellowships, the Gottschalk Medal of the Academy of Science, the President's Medal of the Australian and NZ Society for Cell and Developmental Biology, the Gold Conservation Medal of the San Diego Zoological Society, and the Distinguished Scientist award of the UK Society for the Study of Fertility, and a Eureka Prize for mentorship of young scientists in 2015. She was elected a Fellow of the Australian Academy of Science in 1997, was Vice President from 2011 to 2015, and awarded an Officer of the Order of Australia in 2013.

Margaret Friedel

Dr Margaret Friedel is an expert on the ecology of the Australian rangelands having spent her career living in and studying this fascinating system. Margaret obtained her BSc and PhD degrees from the University of Melbourne in 1967 and 1973. She then joined CSIRO based in Alice Springs where she initially worked on rangelands pasture production systems, before broadening her research to rangelands ecology and management, particularly vegetation dynamics and fire management. She was Officer in Charge of the Alice Springs Laboratories from 2002 to 2009 where she led CSIRO's rangelands research team and inspired many scientists to work on understanding the complexities of the Australian arid zone. Margaret is well known for her engagement with the community and landholders, and her approach to integration of social, economic and ecological values in management of rangeland ecosystems. Margaret was president of the Australian Rangelands Society from 1981 to 1982, and a member of the Commonwealth Government's State of the Environment Land Resources Reference Group from 1994 to 1996. In 2007, Margaret was awarded the Australian Public Service Medal and the Desert Knowledge Research Award, and received the US Society for Rangeland Management's Outstanding Achievement Award in 1996. She was appointed as a Fellow of the Australian Rangeland Society in 2017 in recognition of her outstanding contribution to rangeland science. Since retirement in 2010 she continues to contribute to research initiatives and natural resource management through scientific leadership and active research.

Helene Marsh

Professor Helene Marsh FAA FTSE has been an inspiration to scientists in marine ecology for many years. She obtained a BSc Hons from the University of Queensland in 1968 and a PhD from James Cook University in 1973. Helene worked for a year at CSIRO and had a year at the British Museum before spending the rest of her career at James Cook University. She was awarded a personal chair in Zoology in 1991, and was Head of Department of Tropical Environmental Studies and Geography from 1994 to 2000, then Dean of Graduate Research Studies until her retirement in 2018. Helene is internationally recognised for her expertise in marine biology, particularly in the ecology and conservation of dugongs and other marine megafauna. Helene focused her research in applied science and was highly instrumental in the application of interdisciplinary science to inform policy settings and practical solutions in marine conservation and protected area management, particularly the Great Barrier Reef Marine Park. Helene served as the chair of the Queensland Marine Parks Consultative Committee from 1991 to 1992, and has been Chair of the Great Barrier Reef Consultative Committee since 1998 and Chair of the Sirenia Special Survival Commission of the International Union for the Conservation of Nature since 1985. She also serves as chair of the national Threatened Species Scientific Committee and is a member of the Australian delegation to the World Heritage Committee. Helene was honoured with a Distinguished Service Award by the Society of Conservation Biology in 2008, and the Aldo Leopold Award from the American Society of Mammalogy in 2009. In 2010 Helene was elected a Fellow of the Australian Academy of Technological Sciences and Engineering, and in 2015 a Fellow of the Australian Academy of Sciences.

Unsung heroes

We wish to acknowledge the many other women who have made untold contributions to improving our knowledge in conservation science, and in doing so have inspired those around them in ways they are likely unaware of.

Common experiences

The stories we highlight in this special issue have some common experiences that we suggest are issues familiar to those who have gone before us and likely to be faced by those coming after us.

One of the most compelling themes to the stories is the passion and enthusiasm for the natural environment that these women have had since their youth. This passion, whether for species or landscapes and ecosystems, resonates through the stories of our women and is clearly a driving force in their desire to make their contribution to society. Some of the stories are told quite beautifully, weaving the science with the stories of people and landscapes, enabling us to see the fierce connection between the science and the landscape and its biota.

The stories also demonstrate the multiple pathways that women have taken in their careers, highlighting that there is no single path to follow and that contributions to conservation science can be made in a multitude of ways. Some women have followed academic careers, while others have chosen to make their contributions through non-government conservation

organisations and government agencies. A common thread is the desire is to find ways to bridge the gap between science, management and on-ground implementation. Increasingly, women are moving between traditional academia and more management and policy-oriented positions at different stages in their careers to suit their lifestyles and aspirations. We welcome this flexibility, the diversity of opportunities it provides, and the better outcomes for conservation that will eventuate as a result.

A feature of many of the stories is the sense of satisfaction derived from working collaboratively across disciplines and with a variety of scientists, policy, managers and practitioners to achieve conservation outcomes. Working in multidisciplinary collaborative teams in this way allows us to bring complementary perspectives to the task and learn from each other. Although the capacity for multidisciplinary collaboration does not belong exclusively to women, it is clear that this type of approach appeals strongly to many of our women conservation scientists.

A striking point from many of the stories, that we hope is changing now, is that many of the women had few female role models. While there were some women in senior positions, these were few and most women had little contact with them. However, it is clear that this did not deter our women scientists from forging their own chosen path, and making a difference through their field of work. Many of them acknowledge male mentors, who supported the career goals of their female colleagues.

We suggest that there are always difficulties and setbacks in any career no matter how easy it may seem when looking on from the outside. Science is a career that is generally not conducive to taking time out, whether that is to have children or meet other demands, and it can be challenging to move back

in when desired. Yet the stories highlight the resilience and determination of the women to overcome these difficulties and the strong desire to continue to make a difference even when it is challenging. Indeed, that may be when we make our most important contributions.

Finally, from these stories there is a strong sense of these women conservation scientists seeking to embrace diversity, to inspire other young women to take up the challenge of a career in conservation science, and to encourage our colleagues to make the workplaces of the future welcoming places for everyone where all contributions are valued. As not-so-early career conservation scientists, we are frequently impressed at the passion, drive and sheer competency and skills of the next generation coming through who will lead conservation research into the future. We feel that the field is in good hands!

Conflicts of interest

The authors declare no conflicts of interest.

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