# The critical value of long-term field studies and datasets: an editorial perspective

**Daniel Lunney[1,2,3], Chris R. Dickman[2] and Martin Predavec[4]**

[1]Office of Environment and Heritage NSW, PO Box 1967, Hurstville, NSW 2220

[2]School of Life and Environmental Sciences, University of Sydney, NSW 2006

[3]School of Veterinary and Life Sciences, Murdoch University, WA 6150

[4]Royal Zoological Society of NSW, Mosman, NSW 2088.

ABSTRACT

The 2016 annual forum of the Royal Zoological Society of NSW was entitled: "The critical value of long-term field studies and datasets". As Charley Krebs and co-authors comment in their paper, if there is one overall limitation on our ecological understanding, it is that our generalizations depend too much on short-term studies. All the authors in this theme edition of the *Australian Zoologist* identify the key reasons why long-term studies and datasets are important. David Lindenmayer states that long-term ecological research and monitoring studies are critical to tracking the state of the environment, assessing the effectiveness of management interventions, and informing policy and practices. White and Travers, in their 38-year study of the changes in frog communities in response to sand mining, conclude that the impact of mining does not disappear as a result of rehabilitation work, no matter how good it is. Brad Law takes another tack, noting long-term research on Australian bats as being glaring in its absence. He points out that long-term data are vital for understanding climate change impacts and other environmental changes resulting from management practices, such as timber harvesting or fire. Law concludes with the observation that improved technology has led to major advances in the study of bats, and firmly asserts that the degree of difficulty is no longer a reason to avoid studying bats. Plenary sessions were a feature of the forum. With the skilful facilitation of the plenary sessions by Paul Willis, many general and novel ideas emerged that were the result of listening intelligently to each of the individual accounts. Collectively, the authors and the participating audience demonstrated that there is critical value in long-term field studies and datasets. We highlight the key points and themes that emerged from the forum in this editorial perspective.

Key words: monitoring, research, arid zone, threatened species, Leadbeater's Possum, commercial harvest, logging, Carnaby's Cockatoo, mining, dingo, citizen science, climate change, lost data.

DOI: https://doi.org/10.7882/AZ.2018.045

## Introduction

### The flyer

The 2016 annual forum of the Royal Zoological Society of NSW was entitled: "The critical value of long-term field studies and datasets". It was held at the Australian Museum on 5 November. The success of the day is reflected in the diversity of the papers presented at the time and in this theme edition, the length and depth of study behind each of them, and the lively plenary sessions, which were recorded and published here (lightly edited). In the two following paragraphs, the program flyer presented the aims of the day:

> *Long-term biological data sets are a critical resource for understanding environmental changes. For example, long-term field studies are essential for understanding the ecological processes that govern the sizes of populations and the structure of communities. Initial data from these studies allow us to establish reference conditions from which future changes (e.g. effects of climate change, habitat changes) can be detected. Over the long-term, the data help define the limits of natural variation; identify extralimital variations in faunal responses and their causes; where necessary, help identify the need for active environmental management; and help with both monitoring and interpreting the effectiveness of these actions. Equally important are the datasets from these studies which are crucial sources of information for present and future generations of researchers, environmental managers and policy-makers. Yet the current political and economic climates in Australia favour the allocation of research and environmental management funds to short-term projects.*
>
> *The Royal Zoological Society of New South Wales' Forum will present the findings of some long-term studies, particularly field ecological studies from Australia. These will range from terrestrial to marine studies, and encompassing arid through to forest environments, intertidal through to ocean environments, and projects that are run by universities, government agencies and community groups. The forum will also discuss the current tools and repositories used to archive field data, and how they assist other researchers and managers to discover and use the data. The critical importance of such studies and*

*datasets in helping us understand and manage the natural environment will be discussed, and the need to ensure that funding for long-term field studies will continue into the future will be explored.*

### Theme edition

This theme edition of the Society's journal *Australian Zoologist* captures the spoken papers and the four plenary sessions held during the day of the forum, as well as posters, which make an important contribution to this edition. The cover photo of the eastern long-necked turtle *Chelodina longicollis* can be considered symbolic of long-term studies. It does seem to take a very long time to get very far. Selecting to study the fast-moving hare is tempting, but the moral of Aesop's fable of the hare and the tortoise is that the tortoise won, the hare fell asleep and could not catch up. Ricky Spencer (2018), the author of the turtle paper, puts his finger on why long-term studies are essential. As Spencer points out, freshwater turtle populations are globally threatened by many factors and their longevity requires monitoring for decades to assess changes in population size, yet few long-term studies exist. Documenting population numbers and trends is essential for identifying and conserving imperilled populations; however, the impacts of many current threats may render turtle populations endangered well before declines become apparent.

## The hurdles

From one viewpoint, you need a sense of humour as you reflect on your own long-term studies. There is one thing that we are all certain of: undertaking long-term studies ages the researcher. Consider a photo of yourself in the opening years of your study, then look at current photos. Time will have taken an inevitable toll (although it has been very kind to Denis Saunders –Saunders and Dawson 2018), and while everyone else laughs when the photos are set side by side, your comfort is the value of the long-term dataset. What this means in most cases is that it has been a lead researcher, a champion, that has held on to the vision, can see the future, understands the past and deals with the myriad administrative trials to keep the project alive. Forest plots burn, sites in arid and semi-arid landscapes endure droughts, fires and floods that imperil the project, coastal sites are subject to an ever-expanding human population, and then there are the issues of recurrent funding, staff, changing animal ethics requirements, changes to administrative procedures, the hazards of storing data, new land managers, new legislation, new governments and your own health and personal life. Then there is the imperative of taxonomic stability, which as Heterick and Majer (2018) point out is the need for reliably identified lists of species of one or more groups of taxa, virtually mandatory for decision making by stakeholders in environmentally-based long-term research. This is hardly an encouraging list of hurdles just to count some birds, or ants, or frogs using techniques which may have been superseded. But even if you add the new techniques, you need to retain the original techniques to ensure comparability of the data across the decades. Cross all those barriers, then you reach the environment outlined by Greenville *et al.* (2018) where conducting long-term field-based research poses some unique challenges due to the harsh environmental conditions or extreme weather events that may be encountered, such as those likely to occur in arid environments. Fieldwork issues, they describe, can arise from vehicle breakdowns, wildfires and heavy rainfall, all of which can delay or even cancel data collection. In addition, long-term monitoring typically requires multiple observers, which may add observation bias to estimates of measured parameters. They have come up with an intelligent response to the increasing need to develop new statistical techniques that take advantage of the power of long time-series datasets that also are incomplete. They discuss multivariate autoregressive state-space (MARSS) modelling; a relatively new statistical technique for modelling long-term time-series data. MARSS models allow users to investigate and more reliably interpret incomplete datasets that arise when some values in the time series are missing.

Given the array of hurdles for anyone planning a long-term study, or serendipitously finding themselves presented with the opportunity to continue a project into the realm of a long-term study, we need now to look at the plusses, the real reasons we collect long-term data. We need to ask what value such datasets hold for biological interpretations of questions in ecology, palaeontology, climate change, the effects of natural hazards, and the interaction of factors, such as weather, competitors, predators, invasive species or the impacts of human settlement and disturbance.

## The veterans

Krebs and colleagues (Krebs *et al.* 2018) are veterans of long-term studies, and their research has allowed them to draw some strong conclusions. They note that every scientific study raises more questions than it answers, and that this is the way of scientific progress. They comment that if there is one overall limitation on our ecological understanding it is that our generalizations depend too much on short term studies. This, they say, is changing slowly and our ecological wisdom has retreated from the simple universal theories of the 1970s to a more balanced view of the complexity of ecological interactions.

If there has been an outstanding advocate of long-term research and monitoring, it is David Lindenmayer. His contribution to this theme edition presents a pithy summary of his sustained promotion of long-term studies (Lindenmayer 2018). His paper opens with the view that long-term ecological research and monitoring is critical to tracking the state of the environment, assessing the effectiveness of management interventions, and informing policy and practices. He laments the fact that, despite the importance of long-

term ecological research and monitoring, such studies are not particularly common. This intellectual gap, he says, is most likely because it remains incredibly hard to maintain long-term studies. He lists the barriers, and any one of these would be enough to deter the faint-hearted ecologist. It does take the stamina exhibited by David Lindenmayer to sustain long-term research and monitoring. He has our full support, especially since he continues to apply his findings to contemporary environmental issues, such as forest logging, threatened species survival and promoting biodiversity conservation on rural lands. The cover of the previous edition of *Australian Zoologist* (Vol 39, no 3, 2018) features Leadbeater's Possum *Gymnobelideus leadbeateri*, a species wilting in a world of persistent logging and emblematic of being on the brink of extinction, and illustrates the determination of David Lindenmayer to see it survive.

Emma Burns *et al.* (2018) expand on the characteristics of successful long-term studies. They point out that ecological monitoring is distinct from the concept of surveillance, which seeks to detect change but is not sufficiently focused to permit the causes of the change to be understood. Successful ecological monitoring, they identify, needs to be effective in measuring environmental change as well as influential in achieving changes in environmental management, practice or policy. They boldly add that there is a need for monitoring designs that anticipate future needs, including social conflicts, and quantify ecological events to improve risk management and sustainable economic and social development. This view is a purpose-driven approach, and it amply justifies support for long-term research and monitoring. It does also point to an imperative in ecological thinking, namely that there is a need for an ecological conscience, as a relief from grumpiness on the part of ecologists who see the world disintegrating from the impact of an ever-increasing human population intent on bending wild nature to some short-term economic purpose. To make their point clear, Burns *et al.* (2018) identify and explain the eight core characteristics of success for any type of monitoring. Anyone unsure of what is involved in long-term monitoring can reap a benefit here from reading the thoughts of a set of highly experienced researchers in this field of enquiry. Their concluding observation is that social and communication skills are required to maintain enduring relationships with a variety of interests, both within and outside the study team. This point is not peculiar to ecology, or even science, but is necessary to sustain the communication effort if ever a project running for decades is to avoid collapse because it faded from view. This theme edition of *Australian Zoologist* is just one contribution to keeping the principle of long-term studies alive and alerting zoologists and managers to their value to the public and scientific debates on so many issues.

It is hard to imagine that Denis Saunders and his engaging Carnaby's Cockatoo *Calyptorhynchus latirostris*, an endangered Western Australian endemic, are not among the most well-known of Australia's ornithologists and cockatoos (Saunders and Dawson 2018). Denis and his colleagues have conducted a successful campaign to make their studies an exemplar of the importance of long-term research. Just to glimpse a few of their insights, they start with the more obvious that, as a result of their long-term study, much is known about Carnaby's Cockatoo, and its conservation needs. Of considerable concern, not confined to this cockatoo or even WA, the research also demonstrated that natural hollows are being lost at a rate that exceeds their natural replacement. They then make a more general point, and this is where there is a national overlap in conclusions. They conclude that long-term studies are essential to gain an understanding of the ecology and behaviour of our biota, particularly long-lived species, and are essential to studying a range of seasonal conditions and providing more chances of recording stochastic events such as extreme climatic events and bushfires. They make an important point that, on the basis of their research, it may not be necessary to collect data every year. They then add a personal note, which will resonate with others with 40 years or more of hard-won time series data behind them, that a potential problem for their study is one of succession of researchers: others will need to take over the conduct of the study from DAS and RD or it will lapse.

In one sense, Tony Saunders (2018) has escaped the problem of who will take over. The woodlands on the Cumberland Plain, in the western part of Sydney, have had a succession of skilled bird observers, as you might expect as part of a large city. Tony Saunders has drawn on six decades of careful observation and recording by some of the well-known names in Australian ornithology. As you might imagine, given the rapid growth of Sydney since the World War II, there have been many changes. Tony Saunders' closing point is grim: if the current trends continue, it is likely that we will lose nearly half of the 59 species over the next few decades unless efforts are made to protect and enhance the woodland habitats of the Cumberland Plain.

## Ants and the lesson of a lifetime

Western Australia and the continent's east coast are separated by a long flight, but biologically, they share some striking similarities as well as differences. Majer's and Heterick's (2018) invertebrate studies could apply anywhere in Australia. The last paragraph in their paper, clearly by Jonathan Majer, is the lesson of a lifetime: "Because of my experience gained from a lifetime studying ants I consider that truly informative long-term studies are possible, if some foresight and commitment is made. Long-term studies provide definitive and irrefutable evidence of impacts and changes in our environment."

Their final sentence is crucial: "Finally, we reiterate that although this commentary has resulted from studies on ants, much of what has been said could just as easily be applied to other taxonomic groups." The multiple lessons here identify a cohesiveness in the thinking of those who study ants, cockatoos, turtles or possums, or who work in mine sites, forests or the arid zone.

The arid zone ant study by Gibb *et al.* (2018) asked: over what timeframes do desert ants respond to variation in climate and resources? Their answer, in part, states that responses to resource availability over long time frames (cumulative lags) are relatively stable, while short-term responses (standard lags) are stronger, but highly idiosyncratic, indicating that high cumulative resource availability promotes ant abundance and diversity, while short-term pulses in resource availability have less predictable impacts. Their paper opens with the statement that the need for long-term studies to identify and understand the temporal drivers of abundance has become increasingly obvious as ecologists have begun to recognize the importance of natural and anthropogenic changes in ecosystems that occur over a wide range of temporal scales. This is in part a general statement, but in part a far-reaching conclusion from their study.

In their study on the effects of fire on invertebrates in Australian temperate and sub-tropical forests, York and Lewis (2018) identify the value of long-term experiments, pointing out that these are important when studying the effects of various fire regimes on invertebrate assemblages because responses often take time to be expressed, and may follow changes in habitat availability associated with interactions between components of the fire regime. They sensibly make the economical recommendation that ecological studies continue to utilise long-term study sites through monitoring programs to improve our understanding of how invertebrate taxa respond to fire regimes. They make the observation that potential changes to the population equilibrium of a species as a result of a prescribed fire regime are more difficult to accurately detect in short-term studies that focus on only one or two burns, particularly given the confounding short-term changes to habitats immediately after a prescribed fire. They finish their paper with a statement and a plea: long-term ecological studies are critical for providing key insights into ecosystem function, and it is essential that land management agencies continue to support them and integrate their findings into future fire mitigation strategies.

## Frogs, mines and national parks

In their 38-year study of the changes in frog communities in response to sand mining in the Myall Lakes National Park, New South Wales, White and Travers (2018) found that frog community composition fluctuated dramatically during and immediately after mining. The changes were driven by changes in pH, salinity and emergent plant cover as a direct consequence of mining disturbance. They found that the frog populations at their dunal pond and swamp sites became more stable 20 years after the cessation of mining, but also that neither site has returned to its pre-mining species composition and the impacts of mining still remain. In a blunt, but thoroughly justified conclusion, the authors demonstrate that the impact of mining does not disappear as a result of rehabilitation work, no matter how good it is. They also determine that the environmental changes to ecosystems are not fully understood and that the science of mine site recovery is not advanced enough to enable full recovery after mining. In their view, the minimum that miners and other drivers of large-scale land impact activities should be obliged to do is to monitor and record the long-term impacts that their actions have created. It is, they state, only by creating a long-term database that proactive solutions to environmental change can be addressed.

Arthur White (2018) and the Frog and Tadpole Study (FATS) Group of New South Wales Inc feel a strong sense of achievement in that Wallingat National Park is the product of long-term, specialised, community-based science. The fauna records supplied by FATS (and other natural history groups), they show, document a rich and diverse fauna in Wallingat State Forest, including 26 frog species, 40 reptile species, 30 mammal species and over 100 bird species. These data, they state, paved the way for the gazetting of 6,557 ha of Wallingat State Forest to become Wallingat National Park, mostly due to the rich biodiversity and faunal significance demonstrated by the FATS surveys. FATS continues to survey in Wallingat NP and to compile a record of changes in the frog communities. This is a rewarding outcome of long-term, community-based, science.

## New techniques: camera traps and ultrasonic detectors

In asking, how long is a dingo's tale?, Ballard *et al.* (2018) consider the impacts of sampling design on our understanding of dingo ecology. They recognise the poor outcomes from research that has been skewed towards short-term, snapshot investigations. They employed continuous monitoring with camera traps and found that the benefits of long-term, more intense datasets are that they are clearer, more versatile and much more useful than simple snap-shot indices. Among their concluding comments is that one of the team has been working in a New England field site, where Bob Harden's team studied dingoes in the 1960s, 70s and 80s, and that their group continues to conduct research there and at replicate sites across north eastern New South Wales with continuous monitoring and new technologies that Harden's group could only have dreamed of. They recognise that they now have the longevity, capacity

and experience to analyse the ecology of these sites over a much longer and more informative period than is possible in a PhD or average research grant cycle.

Long-term research on Australian bats has been identified by Brad Law (2018) as being glaring in its absence. Unlike many other taxa, base-line data by which we can identify changes in status over time are virtually non-existent for bats, yet, as Law points out, long-term data are vital for understanding climate change impacts and other environmental changes resulting from management practices, such as timber harvesting or fire. Law's paper is entitled: "Long-term research on forest bats: we have the technology." Its significance lies in the value of new technology to study this cryptic group of animals. Under the heading, "Ultrasonic detectors in forests", Law makes the crucial point that improvements in technology mean we can now collect and analyse vast quantities of bat echolocation call data using ultrasonic detectors. These data can be used as an index of activity to monitor changes over time. Law concludes with the observation that improved technology has led to major advances in the study of bats, more so than for many other taxa, although no single technique provides all the answers to bat ecology, rather each captures a different piece of the puzzle and, most importantly, each can be applied over long periods of time. Tellingly, Law firmly asserts that the degree of difficulty is no longer a reason to avoid studying bats.

## Too few and too many

A team of volunteers has been monitoring Bush Stone-curlews *Burhinus grallarius* for almost two decades on the Central Coast of NSW. Cath Price *et al.* (2018) spell out the lessons learnt. The findings show that the number of breeding pairs fluctuates between just 1 and 6, and can increase relatively quickly, but juvenile dispersal south to highly urbanised and dangerous sites in Sydney has become a population 'sink', undermining population recovery. The long-term banding observations, Price says, have been fundamental to understanding how juvenile dispersal affects Bush Stone-curlew population dynamics. A primary management conclusion is to build resilience into the population by protecting and managing current nesting habitat as well as expanding the area supporting suitable sites. These actions are crucial for increasing the number of breeding pairs, and the size and stability of the population.

In contrast to the plight of a declining species, the paper by Lunney *et al.* (2018) examines the research and monitoring of populations of kangaroos in New South Wales, which has been running for four decades, making it one of Australia's, and the world's, longest running, large-scale wildlife counts. The aim of this paper is to bring this remarkable dataset to a much wider readership so that ecologists, managers, graziers, conservation biologists, government authorities and others such as those who are hostile to the commercial take of kangaroos have a reliable basis for their decision-making and their actions. As an example of the scale and intensity of kangaroo distribution and harvesting in NSW, the total number of kangaroos estimated to be present in the 14 commercial zones in 2017 was 17,457,257. The short answers to regular questions about kangaroo resilience in relation to commercial harvesting, or about allowing culling where rural landholders are adversely affected by kangaroo numbers, are that the data show the kangaroo populations of NSW to be large and widespread and not declining because of either the commercial harvest or culling. While harvesting and culling remain as political matters, the debate needs to be based on long-term datasets that are readily accessible and reliable. In our view, these datasets not only fulfil that requirement, but are textbook material; they can be summarised into one graph that covers decades, or expanded to show the fluctuations in the numbers of each species in each zone for each year.

## Plenary sessions

With the skilful facilitation of the plenary sessions by Paul Willis, many general ideas emerged that were the result of listening intelligently to each of the individual accounts. Consider the following exchange: Cath Price asked: I was wondering if all of the speakers could provide any tips or strategies for younger researchers coming through as to how we get funding for longterm studies and engagement from government agencies for longterm monitoring studies, using your kind of wealth of experience. David Lindenmayer replied: One of the other things that's really important is that many of our ecological colleagues have regarded monitoring as secondrate science and haven't engaged. That just has to stop because that means we're going to predestine ourselves to be irrelevant. So, the concept of management and policy relevance is important. If we can prosecute the case about the importance of what we're doing, and the relevance of datasets, and how they can often be reanalysed in different ways to answer different questions, I think that will push agencies and governments to take notice.

At the outset of the second plenary, Paul Willis noted a theme that came through this session, which was the underlying trends of climate change: essentially, no matter how long your dataset, you're looking at a system in a state of flux and you don't have any baseline of a preflux, preclimate change model. Jonathan Majer commented: it is fortuitous, or unfortunate, in Western Australia, that I happened to start monitoring ants at exactly the time the climate changed, but I agree, it can be a problem. Alan York added that weather stations were set up across his Victorian experimental study area, and as the study

progressed, he and his team could include climate as a factor. So it is important that these other variables are collected as well as the variable of interest.

In plenary session 3, Paul Willis commented that: my experience, whenever you're dealing with volunteers, is you have some that are hyperenthusiastic and maintain that enthusiasm, you have others that come in with less enthusiasm. Those sorts of extrinsic factors can have a dramatic effect on the quality of the data collected. The continuing exchange on this point has wide relevance to projects with volunteers. *Paul:* And Arthur, you don't get off lightly on this particular question. Even if you were the only data collector, you did make the point that you were more enthusiastic in the early years. You would make three visits to your sites each year and that's now dwindled down due to less enthusiasm. Do you think that that difference in effort is going to affect the dataset? *Arthur White*: That was one thing I wasn't sure of myself, I have to admit, and it wasn't until more recently when we've actually started doing some statistical analysis that, fortunately, it's turned out not to have had an impact at all, which is great. *Paul:* That was lucky. *Arthur*: Well, it wasn't. It's only because we had such a long run of good data prior to it. Had I not had that, if that didn't exist, then, yes, this would have got very weak all of a sudden, and I might have had a dataset that I just couldn't interrogate at all.

Towards the end of plenary 4, Paul Adam introduced a difficult topic about ownership and rights to people's data. I would have agreed with Terry Dawson, said Paul, that there's this huge problem of the large numbers of PhD theses which never get any further than sitting in the library. But when I was head of school some years ago, I had a very interesting event where I got an email from the library saying that somebody had asked for access to a thesis because they would like to use the data in it, but the library didn't know where the person was. Could I contact the former student and get permission, and it turned out, unfortunately, that this particular person had died shortly after they graduated. Then the library said, "Well, without permission, we can't release the information at all." I pursued this, and eventually the legal office went out to external counsel whose advice was, no, given that the person concerned hadn't expressed at the time they submitted the thesis any intent to make the data available to other people other than himself, given that he didn't mention it in his will - so that's a lesson to you all - it was effectively embargoed for all time. Mike Archer added to the discussion: Yes, dead data. I don't know, Paul, whether I'm talking about the same person as you are, but certainly I've had a PhD student die just as they were about to submit a thesis, there was one little bit to finish. We went to the postgraduate board. Sue [Hand] and I were really good friends with the student, there was a really good relationship. We said, "Look, we'll just finish it off so they can get a posthumous PhD," and we got the same kind of reaction.

The discussion continued, with Pat Hutchings reporting that she had a slightly different situation. Pat stated that recently she tried to find an Honours thesis on the baitworm that's collected in Moreton Bay, and Queensland University accepted that, yes, the student had got his Honours. No copy? Well, perhaps it's in the departmental library. No copy. The person's supervisors have long since retired, we can't find the student, so that data are completely lost and it's the only data on a commercially important species of worm. Perhaps that's not terribly important to some people, but trying to look at management strategies, it's just ridiculous. Mike Archer added: we're all very sensitive to this problem. We're all sitting in institutions with shelves of theses and sometimes you can't find them. So UNSW has made a recent decision, at least within the biological sciences, to digitise all the theses. It's a great idea, because then it minimises the risk of the kind of thing you've had to deal with, Pat.

Paul Willis closed the session with the same wonderful wit with which he started the day: I know there's plenty more commentary, you guys come alive and you want to start asking questions right at the end of the day. Why is it? It's just like on a palaeontology dig; the most important specimen you'll find will be on the last day….. Can I please get you to put an extra loud round of applause, not only for our speakers this afternoon, but for all the speakers presenting today.

The Plenary sessions are so valuable in that they allow the audience to participate in the day, and it is evident that there are so many more ideas and themes that could be followed. While the many authors in this forum, now this theme edition, have given us a wide range of ideas to reflect on, it is also apparent that we could run the day all over again with an expanded set of ideas and examples. However, collectively, the authors and the participating audience have demonstrated, beyond any doubt, that there is lasting and critical value in long-term field studies and datasets.

## Acknowledgements

There are many people to thank for such a successful day: all fellow council members for their input, especially Stephen Ambrose for suggesting the title; Peggy Eby for managing the computer; Pat Hutchings, Adele Haythornthwaite, Stephen Ambrose and Peter Banks for chairing a session, and to Paul Willis for his skills in facilitating the discussions in the plenary sessions. Spark and Cannon recorded the day. We are also indebted to the many referees for their quiet contribution, and to all the authors for their presentations and their posters and papers.

## References

**Ballard, G., Fleming, P. J. S. and Meek, P. D. 2018.** How long is a dingo's tale?: Impacts of sampling design on our understanding of dingo ecology. *Australian Zoologist* **39(4)**:579-588. DOI: https://doi.org/10.7882/AZ.2018.034

**Burns, E. L., Tennant, P., Dickman, C. R., Gillespie, G., Green, P. T., Hoffmann, A., Keith, D. A., Lindenmayer, D. B., Metcalfe, D. J., Morgan, J. W., Russell-Smith, J. and Wardle, G. M. 2018.** Making monitoring work: insights and lessons from Australia's Long Term Ecological Research Network. *Australian Zoologist* **39(4)**:753-766. DOI: https://doi.org/10.7882/AZ.2018.030

**Gibb, H., Grossman, B. F., Dickman, C. R. and Wardle, G. 2018.** Over what timeframes do desert ants respond to variation in climate and resources? *Australian Zoologist* **39(4)**:644-655. DOI: https://doi.org/10.7882/AZ.2018.016

**Greenville, A. C., Nguyen, V., Wardle, G. M. and Dickman, C. R. 2018.** Making the most of incomplete long-term datasets: the MARSS solution. *Australian Zoologist* **39(4)**:731-745. DOI: https://doi.org/10.7882/AZ.2018.018

**Heterick, B. and Majer, J, 2018.** The taxonomic stability imperative. *Australian Zoologist* **39(4)**:625-630. DOI: https://doi.org/10.7882/AZ.2017.031

**Krebs, C.J, Boonstra, R., Kenney, A. J. and Gilbert, B. S. 2018.** Hares and small rodent cycles: a 45-year perspective on predator-prey dynamics in the Yukon boreal forest. *Australian Zoologist* **39(4)**:722-730. DOI: https://doi.org/10.7882/AZ.2018.012

**Law, B. S. 2018**. Long-term research on forest bats: we have the technology. *Australian Zoologist* **39(4)**:656-666. DOI: https://doi.org/10.7882/AZ.2018.028

**Lindenmayer, D. 2018**. Why is long-term ecological research and monitoring so hard to do? (And what can be done about it). *Australian Zoologist* **39(4)**: 574-578. DOI: https://doi.org/10.7882/AZ.2017.018

**Lunney, D., Purcell, B., McLeod, S., Grigg, G., Pople, T. and Wolter, S. 2018.** Four decades of research and monitoring the populations of kangaroos in New South Wales: one of the best long-term datasets in Australia. *Australian Zoologist* **39(4)**: 782-798. DOI: https://doi.org/10.7882/AZ.2018.040

**Majer, J. and Heterick, B. 2018.** Planning for long-term invertebrate studies – problems, pitfalls and possibilities. *Australian Zoologist* **39(4)**:615-624. DOI: https://doi.org/10.7882/AZ.2017.009

**Price, C. J., Morris, A., Staines, G., Payne, R. and Smith, J. 2018.** Leaving home but nowhere to go: lessons learnt from almost two decades of Bush Stone-curlew *Burhinus grallarius* monitoring on the Central Coast of NSW. *Australian Zoologist* **39(4)**:769-783. DOI: https://doi.org/10.7882/AZ.2018.049

**Saunders, A. S. J. 2018.** Trends in woodland bird populations on the Cumberland Plain, New South Wales, from long-term datasets. *Australian Zoologist* **39(4)**:673-695. DOI: https://doi.org/10.7882/AZ.2018.028

**Saunders, D. A. and Dawson, R. 2018.** Cumulative learnings and conservation implications of a long-term study of the endangered Carnaby's Cockatoo *Calyptorhynchus latirostris*. *Australian Zoologist* **39(4)**:589-697. DOI: https://doi.org/10.7882/AZ.2017.010

**Spencer, R-J. 2018.** How much long-term data are required to effectively manage a widespread freshwater turtle? *Australian Zoologist* **39(4)**:566-573. DOI: https://doi.org/10.7882/AZ.2018.017

**White, A. W. 2018.** Wallingat National Park: the product of long-term, specialised, community-based science. *Australian Zoologist* **39(4)**:711-721. DOI: https://doi.org/10.7882/AZ.2018.027

**White. A. W. and Travers, S. 2018**. Swimming in sand: long-term changes in frog communities in response to sand mining in the Myall Lakes National Park, New South Wales. *Australian Zoologist* **39(4)**:696-710. DOI: https://doi.org/10.7882/AZ.2017.017

**York, A. and Lewis, T. 2018**. Understanding the effects of fire on invertebrates in Australian temperate and sub-tropical forests: the value of long-term experiments. *Australian Zoologist* **39(4)**:631-643. DOI: https://doi.org/10.7882/AZ.2017.020

PHOTOGRAPHS

Audience, Emma Burns with microphone. (Emma is also an author of a paper in this theme edition of *Australian Zoologist*.)

All photos by Dan Lunney.

Audience, Peter Banks with microphone.

Audience, Peter Jarman with microphone.

PHOTOGRAPHS

Audience, Terry Dawson with microphone.

Audience, Terry Dawson with microphone.