Australian National University

CSIRO

Centre for Biodiversity Analysis

cba.anu.edu.au

2016-17 Annual report

October 2017

1. Director's summary

2016-17, our fifth year of operation, has been another excellent 12 months of collaborative science across ANU and CSIRO, and beyond. The CBA funded six new Ignition Grants, hosted two 3-day workshops, and our fifth conference "Genomics and Collections: Adaptation to Macroevolution". We launched a new workshop series 'TEA Talks' (Techniques in Evolutionary Analysis), that aims to introduce a range of emerging concepts and techniques in evolutionary analysis. Our first two Honours awards students successfully completed their honours program and submitted their theses. The 2017 school-wide review of the Research School of Biology made particular note of the success and value of the CBA several times throughout its report, and emphasised the importance of interacting with CSIRO into the future.

The CBA's initial five-year funding arrangement was scheduled to finished at the end of June 2017. We are pleased to announce that, with contributions from ANU (RSB lab leaders, CMBE and DVCR) and CSIRO (National Research Collections), the Centre for Biodiversity Analysis has been renewed for a further three years.

In its first five years the CBA has built an interactive research community across ~60 ANU and CSIRO labs. The Centre has used its modest resources to develop collaborations via visiting scientists, seminars and the delivery of 14 ECR-focused training workshops, five conferences, and seed funding for over 35 Ignition grants, with 107 researchers and students involved in an Ignition project to date. This building of capacity and community has led to new collaborative research funding (ARC DP, Linkage) and several co-supervised students, and contributed strongly to successful bids for infrastructure (SIEF-RI$10M, including the Ecogenomics and Bioinformatics Laboratory) and research support (CSIRO Environomics Future Sciences Platform 2017-2020, $5.5M; Bioplatforms Australia Oz Mammals Genomes Initiative 2016-2018; $1.1M). The CBA has also been actively building relationships with NGOs and government at the science-policy-management interface, e.g., the 2016 conference on the Interface of Evolutionary Biology and Policy Impact and the editorial in CEED's Decision Point: "Evolutionary biology – what is it good for?".

Over 2017-20 we will continue to build on the activities of the last five years and, depending on the interests of CBA members and participants, provide opportunities to broaden the Centre's focus to include wider applications of evolutionary biology. New activities will include funding for cross-disciplinary Synthesis Groups and targeted recruitment of joint ANU-CSIRO Honours and PhD students, with the aim, along with continuing activities, of further strengthening interactions across ANU and CSIRO via the National Agriculture and Environmental Science Precinct (NAESP).

In our next iteration we also intend to broaden the capacity and reach of the CBA to include researchers and students from the Institute for Applied Ecology at UC and stronger connections with local industry (e.g. DArT; Questagame). We will also aim to build stronger connections with the Fenner School of Environment and Society at ANU in relation to ecosystem ecology/management and translation of ecological/evolutionary science to policy.

2. Executive summary

2.1 CBA Director and Coordinator

- CBA Director Craig Moritz craig.moritz@anu.edu.au.
- CBA Coordinator Claire Stephens claire.stephens@anu.edu.au (67% position Mon-Thurs; 85% position Mon-Fri from July 2017).
- Located in the Gould Building (Rooms 223-224, 116 Daley Road), Research School of Biology, ANU.

2.2 CBA Liaison Committee members

- **ANU**
  - Justin Borevitz (2012-current) - Division of Plant Sciences, Research School of Biology.
  - Scott Keogh (2012-current) - Division of Ecology and Evolution, Research School of Biology.
- **CSIRO**
  - Andrew Young (2012-current) - National Research Collections Australia, Facilities and Collections.
  - Oliver Berry (Aug 2017-current) - National Research Collections Australia, Facilities and Collections.
  - Ian Cresswell (Aug 2014-July 2017) - Biodiversity, Ecosystem Knowledge and Services, Land and Water Flagship.
  - Owain Edwards (Dec 2013-July 2014) - Ecosystems Sciences.
  - Andy Sheppard (2012-Nov 2013) - Ecosystems Sciences.

2.3 CBA membership

- Currently 53 research scientists and their lab groups are listed as CBA members.
- Lab leaders and research scientists from ANU and CSIRO are from a range of areas relevant to the CBA's core focus of incorporating genomics, bioinformatics and spatial modelling into understanding the evolution of Australia's biodiversity and its protection:

  CSIRO
  - National Research Collections Australia (NRCA), Facilities and Collections (Canberra, Townsville and Hobart).
  - Biodiversity, Ecosystem Knowledge and Services (BEKS), Land and Water Flagship.
  - Agriculture Flagship.
  - Biosecurity Flagship.

  ANU
  - Ecology and Evolution (E&E) and Plant Science (PS) in the Research School of Biology (RSB).
  - Fenner School of Environment and Society (FSES).
  - Department of Archaeology and Natural History (ANH).
  - Centre for Aboriginal Economic Policy Research (CAEPR).
- Postdoctoral fellows and postgraduate students are considered CBA members by affiliation of their lab / research group. They are also included on the CBA email list.
- In March 2017, an email (re-)introducing the CBA was sent (by Karel Mokany, CSIRO L&W) to the CSIRO email network to Land and Water Flagship at Black Mountain and to all of BEKS nationally. We had 25 responses requesting to be added to the CBA email list (8 NRCA; 8 L&W; 3 Biosecurity; 3 Agriculture; 4 Biosecurity; 2 Education).

2.4 CBA website

- cba.anu.edu.au
- Key role is to connect information relevant to the CBA mission and focus across CSIRO and ANU and is used to publicise CBA and other relevant events, highlight our research and advertise funding opportunities and student projects.
- Website includes:
  - Information on the CBA.
  - List of Members and links to their own institutional pages.
  - Research highlights (contributed by ECRs).
  - CBA-funded Ignition projects.
  - Opportunities, including CBA and external grants and funding, student projects and job advertisements.
  - Public policy areas (linked to relevant CBA Highlights, Projects and News and external Department of the Environment biodiversity policy pages).

- News and events, which includes both CBA news and events (e.g. workshops and conferences) and external news and events that may be of interest to CBA members.

2.5 Hardware and equipment

- Contribution to a Research School of Biology (RSB) Small Research Equipment grant for a real-time PCR machine (2017 - $2,000).
- Contribution to the BPA Oz Mammals Project: exome pipeline built by ANU Bioinformatics Consultancy (ABC) (2017 - $12,500).
- Contribution to an acoustic liquid handler (SIEF grant) (2017 - $5,000).
- Contribution to the ANU Major Equipment Committee (MEC) proposal for the purchase of an Illumina NextSeq500 sequencing platform for the experimental genomics facility (2015 - $15,000).
- Contribution to the RSB 2014 Equipment and Infrastructure Scheme - transcriptome analysis software (2014 - $2,000).
- Contribution to the establishment of the experimental genomics facility based at the Research School of Biology (RSB), ANU (accessible to CBA members) (2014 - $15,000).
- Purchase of a large 256 GB RAM node computing cluster located in, and operated by, the Genome Discovery Unit (ANU). Contact Cameron Jack (cameron.jack@anu.edu.au) for details on capabilities and access (2013 - $30K).

2.6 CBA activities

Further details of 2016-17 activities are below (Section 3); a full list of all CBA activities are listed in the Appendix.

- Joint ANU-CSIRO Projects -'Ignition grants'
- Annual conferences
- Workshops
- Seminars
- Policy, outreach and communication
- CBA Mk 2 (2017-2020)

3. CBA 2016-17 activities

3.1 Ignition grants

Each year the CBA funds a number of small pilot projects, called Ignition projects. This funding aims to 'kick-start' new ANU-CSIRO collaborative research, with the intention that results will subsequently form the basis of more substantial research proposals and collaborations.

The scope of an Ignition project needs to be within the CBA's core focus of incorporating genomics, informatics or spatial modelling into the discovery, understanding and/or protection of Australia's biodiversity.

All proposals must show a direct, and genuine, collaboration between at least one member of an ANU and a CSIRO research group. Group leaders, postdocs and/or students may be included on up to two project submissions per funding round.

Figure 3.1 Images from a selection of **Round 7 funded Ignition Projects (clockwise from top left): 1** Landscape genomics of a dryland river keystone species, *Eucalyptus coolabah*: the influence of hydrochory on landscape genetic structure; **2** Phylogeny of the longhorn beetle genus *Rhytiphora* (Coleoptera: Cerambycidae); **3** The untold story of underground communities: fungi and soil seed banks in Mountain Ash forests; **4** Understanding biological invasions: assessing the biosecurity threat of the pink bollworm to Northern Australia.

Proposals may request funding for fieldwork, sample preparation, next-generation sequencing, technical salaries or data analysis. Workshops/meetings that have significant outcomes for future ANU-CSIRO collaborative research may also be funded (although from 2018 funding for workshops/meetings will be transferred to the new Synthesis Group program - see Section 3.4). For the 2012-2013 funding rounds up to $5000 per project was offered. From June 2014, $10,000 per project was made available and requests for up to this amount has continued for subsequent funding rounds.

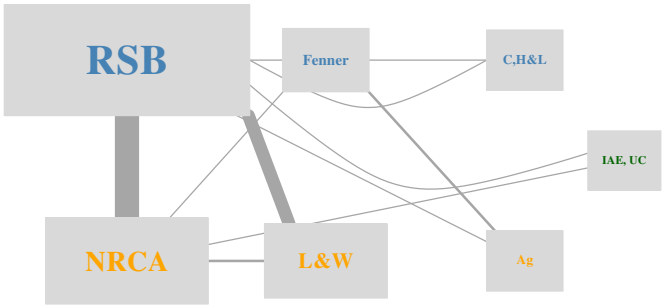
Table 3.1 summarises the six Ignition Projects the CBA funded in our seventh round of grants (a full list of CBA-funded Ignition Projects is in the Appendix).

Table 3.1 2016-17 (Round 7) funded Ignition Projects.

Proposal	$ requested
Uncovering the hare microbiome – implications for invasive lagomorph management (Honours project) John Rathjen, Benjamin Schwessinger, Louis Ranjard Research School of Biology, ANU Robyn Hall, CSIRO Health and Biosecurity, Acton, ACT; Invasive Animals CRC, Bruce	$10K - $5K stipend, $5K lab work (library prep & sequencing)
The untold story of underground communities: fungi and soil seed banks in Mountain Ash forests Elle Bowd (PhD student), David Lindenmayer, Sam Banks, Fenner, ANU Andrew Bissett, NRCA, CSIRO Tom May, The Royal Botanical Gardens, Victoria	$10K lab work (soil testing, library prep & sequencing)
Biodiversity change: A risk factor for human health? Aparna Lal, National Centre for Epidemiology and Population Health, ANU Karel Mokany, CSIRO Land and Water	$4.5K Research Assistant salary; $2K one day workshop
Phylogeny of the longhorn beetle genus *Rhytiphora* (Coleoptera: Cerambycidae) Lauren Ashman (PhD student), David Rowell Research School of Biology, ANU Adam Slipinski, Andreas Zwick ANIC, CSIRO	$10K lab work (MIP probe synthesis & sequencing)
Understanding biological invasions: assessing the biosecurity threat of the pink bollworm to Northern Australia Angela McGaughran, Rob Lanfear, Research School of Biology, ANU Tom Walsh, CSIRO Land & Water	$10K (library prep & sequencing)
The landscape genomics of a dryland river keystone species, *Eucalyptus coolabah*: the influence of hydrochory on landscape genetic structure Jake Gillen, Fenner, ANU David Bush, Australian Tree Seed Centre, CSIRO	$10K (DNA extraction, library prep & sequencing)

3.1.2 Summary of CBA Ignition grant engagement 2012-17

Examination of our Ignition grant recipients over the past 4.5 years (30 projects) reveals the success of the scheme in developing collaborations across participating ANU and CSIRO labs (Table 3.2). Most of the interactions to date are between RSB and NCRA, followed by RSB and L&W. This is not unexpected given the number of CBA members from these groups. It also highlights the other areas that interact with CBA and provides areas to target our activities, particularly Fenner at ANU and Agriculture at CSIRO. It also shows that there is some interest from researchers at the University of Canberra, who we will pursue as a potential CBA partner in the future (see Section 3.7).



ANU: Research School of Biology (RSB); Fenner School of Environment & Society (Fenner); School of Culture, History & Language (C,H&L). **CSIRO**: National Research Collections Australia (NCRA); Land & Water L&W); Agriculture (Ag); **University of Canberra**: Institute of Applied Ecology (IAE)

Table 3.2 Summary of collaborative interactions via CBA Ignition grants

Interaction	N	Location	N people	N projects	N people
RSB-NRCA	19	RSB	53	1	43
RSB-Fenner	1	Fenner	5	2	21
RSB-L&W	10	C,H&L	2	3	7
RSB-C,H&L	1	NRCA	28	4	1
RSB-Ag	1	L&W	16	5	1
NRCA-Fenner	1	Ag	2		
NRCA-L&W	2	IAE, UC	1		
Fenner-Ag	2				
L&W-C,H&L	1				
RSB-IAE	1				
NRCA-IAE	1				

3.1.3 Progress reports (from Ignition grant recipients)

A next-generation phylogenetics approach to explore the immense diversity of Australian thynnine wasps
Thomas Semple (ANU PhD student), Rod Peakall (ANU), Andreas Zwick (CSIRO)

We acquired 96 samples of thynnine wasp and outgroup species from both recent collections and pinned material from the Australian National Insect Collection, with roughly 80% coverage across all genera in the subfamily.

DNA extraction was completed successfully and delivered to the Australian Genome Research Facility for library preparation, target enrichment and high-throughput sequencing of Ultra-Conserved Elements. This process was delayed considerably at the sequencing facility, but has since been completed successfully with consistent yield across almost all samples. Bioinformatics and phylogenetic analysis has been planned out and is due to commence before the end of the year.

How local is local? Landscape genomics in Yellow box

Justin Borevitz (ANU) and Linda Broadhurst (CSIRO)

- ARC Linkage Grant ($375K): 'Landscape restoration genomics for climate adaptation in eucalyptus foundation species'.
- A new Yellow Box (*Eucalyptus melliodora*) subspecies identified.
- Supple, M. A. *et al*. In press. Landscape genomic prediction for restoration of a *Eucalyptus* foundation species under climate change https://doi.org/10.1101/200352

Biogeography of sex reversal and the effects of climate change on reptile sex determination

Clare Holleley (CSIRO), Craig Moritz (ANU), Dan Rosauer (ANU), Arthur Georges (University of Canberra)
Students: Caitlin Cherryh (UC), Meghan Castelli (UC)

This study has successfully tripled the spatial and temporal sampling of bearded dragons and tested for occurrences of sex reversal. We now have genotyped a total of 398 specimens spanning a 37-year period (1980-2017); whereas our last published report included just 131 individuals spanning a 9-year period (2003-2011).

Sex reversal occurrences are geographically clustered and temporally stable, with the highest-incidence occurring on the border of NSW and QLD. This suggests that it is possible for mixed-model systems of sex determination (GSD + thermal override) to exist stably in the short term, with low rates of sex reversal. It also suggests that loss of the heterogametic sex chromosome could be buffered by immigration from surrounding populations.

To understand how the occurrence of sex reversal relates to real-world climate data, we developed models to probabilistically estimate egg incubation date and nest location based on adult capture data. We used this framework to query publicly available climate datasets and estimate the likely egg incubation temperatures in the field. Despite having an increased empirical dataset, we did not detect a significant correlation between predicted nest environment (mean maximum temperature and mean diurnal temperature range) and sex reversal. This suggests that occurrence of sex reversal in the wild might be more closely associated with variability in the physiological threshold for sex reversal (temperature sensitivity) rather than an absolute temperature experienced during development. However, the statistical power of this model could be improved with new information on the age structure of wild populations, life-span in the wild and territory size of female individuals.

DNA extractions from formalin preserved specimens have proved to be challenging and thus we have not yet been able to include these samples in the analyses mentioned above. However, efforts continue and we are optimistic that we will have successful workflow for formalin preserved specimens in 2018, adding another potential 933 specimens from museum collections nationally.

Environmental drivers of Acacia-associated symbiotic microbe diversity

Russell Dinnage, Marcel Cardillo (ANU), Anna Simonsen, Suzanne Prober, Luke Barrett, Pete Thrall (CSIRO)

The main finding we discovered was an interesting (and not initially expected) relationship between the size of an *Acacia* tree and the diversity of rhizobia bacteria in the soil surrounding it, that is not accounted for by climate factors. We suspect it has to do with tree age, and we are exploring several hypotheses to explain it (e.g. island biogeography, niche construction, etc.). These results are reported in Dinnage, R. *et al*. In press. Larger legume plants host a greater diversity of symbiotic nitrogen-fixing bacteria. https://doi.org/10.1101/246611.

Evolutionary processes in Billy buttons

Alexander N. Schmidt-Lebuhn (CSIRO) and Justin Borevitz (ANU)

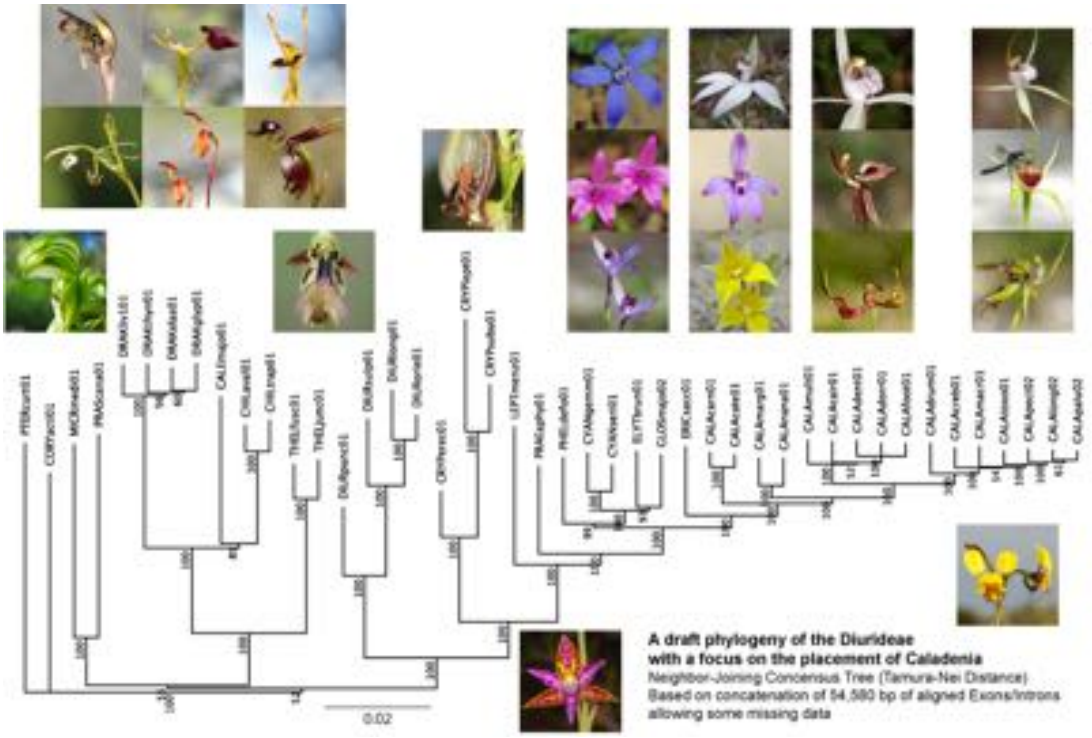
Results from this study have been published: Schmidt-Lebuhn, et al. 2017. Species trees from consensus single nucleotide polymorphism (SNP) data: Testing phylogenetic approaches with simulated and empirical data. *Molecular Phylogenetics and Evolution* 116: 192-201: https://doi.org/10.1016/j.ympev.2017.07.018

An exome capture system for phylogenetic and evolutionary studies in the hyperdiverse orchid tribe Diurideae (Orchidoideae)

Katharina Nargar (CSIRO), Rod Peakall (ANU), Mark Clements (CSIRO), Celeste Linde (ANU), Lars Nauheimer (ATH), Ryan Phillips (ANU)

The project has been successfully completed this year (2017). Activities included:

- The funding from CBA made it possible to expand an ARC funded ANU based project focused on the Australian Caladeniinae to include a wider focus on the Diurideae as a whole.
- The probe set for the exome capture system was developed based on transcriptome data from 11 species spanning the Diurideae and including an outgroup.
- Initial successful sequencing of 190 samples, including 45 representatives spanning the Diurideae was completed in May 2017. The inclusion of these extra 45 samples was made possible by this ignition grant.
- Sequence assembly, locus extraction, alignment and preliminary phylogenetic analysis was successfully completed by July 2017.
- The preliminary results were presented at an International Conference by Rod Peakall: Phillips R, Ruibal M, Wong D Linde C Peakall R (2017): Development of a phylogeny for Australian Caladenia orchids to explore the evolution of specialised pollination. XIX International Botanical Congress, Shenzhen, China.
- A material transfer agreement was signed between ANU and CSIRO to facilitate ongoing collaborative use of the full probe set.
- 96 samples have been submitted for NGS sequencing by AGRF that are using the probes for a phylogenomic project in the orchid genus *Thelymitra* (ABRS funded study, Nargar et al.).
- One grant application (CAT1) has been submitted for a phylogenomic project in *Diuris* based on the developed exome capture system (Nauheimer et al. 2017). Decision pending.
- An example of one of the preliminary phylogenetic trees that was presented at the meeting in China is shown below.



[Genomic Diversity in Australian palms]
Bee Gunn (ANU) and Sarah Mathews (CSIRO)

At the commencement of the CBA ignition grant in August 2016, Bee collected 32 samples of silica-dried leaf material of Australian palms from the living collections of the Royal Botanic Garden NSW Sydney. Genomic DNA was isolated from 38 taxa including three palms from herbarium vouchers from the Gauba Herbarium at ANU.

Probe design for exon capture of nuclear markers was carried out in collaboration with Felipe De Mello Martins at ANU. We downloaded the whole genome sequence of the *Phoenix dactylifera* (date palm) from Genbank and transcriptome sequences from the 1 Kp project for mapping onto the annotated genome sequence. We found that the date palm genome sequence was only partially annotated which made mapping of the transcriptomes for exons boundaries information for bait design a challenge because splice sites could not be determined accurately.

During December 2016, Bee took up a postdoctoral position at the Royal Botanic Gardens Victoria in Melbourne. Whilst she has been focusing on the phylogenomics of the Australian Asparagales, she has continued to investigate new protocols applicable for the palm project through her current job.

In July 2017, Bee attended the XIX International Botanical Congress in Shenzhen, China and was motivated by the many cutting-edge NGS methods presented by colleagues at the meeting. The Hyb-seq (Weitmier et al. 2014) method is an innovative NGS protocol, which combines genome skimming and target enrichment of baits for over 300 nuclear exon and flanking regions. The Palm Phylogeny Working Group (EUNOPS) has an exon bait kit suitable for target enrichment across all palms and we propose to apply this bait kit and protocol for pulling down the nuclear exons for Australian palms for this CBA ignition grant project. This will provide a robust phylogeny for subtribe Ptychospermatinae based on chloroplast and nuclear genomes. Furthermore, our high throughput sequence data may be combined with sequences of palms worldwide generated by the Palm Phylogeny Working Group. This will be a significant contribution for a comprehensive generic level phylogeny of all palms and enlighten the evolutionary history of the Australian palm lineages and their diversification in the global context.

We plan to isolate palm species from the living collections at the Royal Botanic Gardens Melbourne by March 2018 and carry out the library preparation using the Hyb-seq high throughput sequencing protocol and sequencing on the Illumina HighSeq platform by September. Bioinformatics pipeline post sequencing and analyses will occur in November/December.

Developing new methods for using distribution data to identify taxa that can tolerate extreme conditions
Xia Hua, Lindell Bromham, Marcel Cardillo (ANU), John La Salle (CSIRO)
cba.anu.edu.au/research/projects/developing-new-methods-using-distribution-data-identify-taxa-can-tolerate-extreme

Two novel methods have been developed to identify taxa (*Acacia* spp.) that can tolerate extreme conditions (drought) using their current distribution data. Simulation results suggest that these new methods work well. Method I searches for the criteria that have the largest chance to identify known tolerant taxa as tolerant and to identify known sensitive taxa as non-tolerant. Method II offers a complementary approach to Method I by allowing us distinguish situations where a taxon is not able to distribute in more extreme conditions than its current habitats from situations where the taxon has not yet been tested by natural selection under more extreme conditions. The paper 'Using distribution data to identify taxa that can tolerate extreme conditions', for *Systematic Biology*, has been drafted, with the aim to submit early in 2018.

3.1.4 Honours and HDR Students

Honours Awards

The CBA liaison committee has had several discussions about increasing, and better coordinating, the recruitment of HDR students into CSIRO labs. Moving forward, co-supervised student recruitment will be a key focus of the CBA.

From September 2015, as part of the Ignition grant scheme, the CBA has sought proposals for co-supervised ANU-CSIRO Honours projects. Our main goal with this funding is to facilitate ANU honours students spending time in CSIRO labs, providing valuable exposure to CSIRO scientists and research. Up to a $5000 student stipend can be requested as part of these proposals. The proposed projects need to allow for students to have considerable engagement with both their ANU and CSIRO labs.

Two honours projects were funded in the September 2015 round of Ignition Grants. The students commenced their projects in January 2016 and their theses were successfully submitted in November 2016. Their abstracts are available on the CBA web page.

Bill adaptation in parrots: finding loci involved in surface area increases by integrating morphometrics with NGS Keira Beattie (ANU Honours student); Supervisors: Kerensa McElroy (CSIRO), Loeske Kruuk, Janet Gardner (RSB, ANU).

Work from Keira's project has been accepted for publication: McElroy, K., et al. in press. Mitogenomic and nuclear diversity in the Mulga Parrot of the Australian arid zone: cryptic subspecies and tests for selection. *Emu - Austral Ornithology*. Keira is currently a technical officer in the biomedical radiochemistry laboratory at Research School of Physics and Engineering, ANU.

Will polyploidy provide a reproductive advantage in a changing climate? A test case with *Themeda triandra* (Kangaroo grass) Amelia Stevens (ANU Honours student); Supervisors: Lydia Guja, Robert Godfree (NRCA, CSIRO), Adrienne Nicotra (RSB, ANU).

During her Honours year Amelia won the Marilyn Fox Inaugural Talk Prize at the 2016 Ecology Society of Australia's annual conference. She is currently a research technician at CSIRO's Australian National Herbarium, working with Andrew Young's team on plant reproductive biology.

As part of Round 7 of Ignition grants (July 2017), another Honours Award was granted and is currently being advertised for a 2018-19 Honours student (beginning or mid-year start): Uncovering the hare microbiome – implications for invasive lagomorph management. John Rathjen, Benjamin Schwessinger, Louis Ranjard (RSB, ANU), Robyn Hall, CSIRO Health and Biosecurity.

NCRA PhD 'top-up' scholarships and summer scholarships

Over 2016/17 the CBA has helped promote CSIRO's National Research Collections undergraduate vacation scholarships and top-up PhD scholarships:

- A summary slide outlining NCRA summer scholarships was drafted and sent to second semester ANU lecturers teaching in relevant courses (right);
- Relevant scholarship information was sent to RSB third year and Honours student email lists;
- Projects were advertised on CBA webpage and EvolDir;
- Actively coordinated co-supervisor 'match-making' of NCRA project leaders and ANU co-supervisors; and
- "How to apply" notes with relevant dates and links were developed and made available on the CBA webpage for potential PhD students.

With support from Andrew Young (Director NRCA), we are aiming for better coordination for the coming year as the CSIRO awards are advertised too late in the year relative to ANU applications, particularly for international students. The CBA also has agreement from Kiaran Kirk (Dean, ANU College of Science) for international tuition fee waivers if the base stipend is provided CSIRO.

3.2 CBA annual conference

Genomics and Collections: Adaptation to Macroevolution

In collaboration with CSIRO NRCA our 2017 conference explored the relationship between genomics and collections (museums and herbaria). For evolutionary biologists, natural history collections are an immense resource of genomes and phenotypes connected to time and place. For museum and herbarium scientists, new genomic capabilities are becoming real game-changers in how these collections are being used and valued.

The conference was jointly organised and funded by CSIRO's 'Cutting Edge Science Symposium' (proposed by Leo Joseph, Director Australian National Wildlife Collection, CSIRO) and the Centre for Biodiversity Analysis. Speakers were invited from both overseas and locally (Table 3.3) with the CSIRO Cutting Edge Symposium bringing together biologists working both within and outside collections to focus on adaptation. To complement this, the CBA chose speakers to review, assess and plan for the future in phylogenomics and emerging insights into speciation and macroevolution. This was to help take stock on our progress towards realizing the promise of phylogenomics as highlighted in previous CBA conferences, especially the inaugural meeting on Biodiversity Genomics in 2013.

Table 3.3 2017 conference - invited speakers

Speaker	Affiliation
Jeffrey Good	University of Montana
Michael Harvey	Museum of Zoology, University of Michigan
Judith Mank	University College London
Sarah Mathews	Australian National Herbarium, CSIRO
Corrie Moreau	Illinois Field Museum of Natural History
Emily Moriarty Lemmon	Florida State University
Craig Moritz	Australian National University
Rick Sturm	University of Queensland
Paul Sunnucks	Monash University
Luisa Teasdale	Australian National Insect Collection, CSIRO
Simon Tierney	Western Sydney University
Andreas Zwick	Australian National Insect Collection, CSIRO

Table 3.4 2017 conference - participants

Conference participants	N
Invited speakers	**12**
- International	5
- Interstate	3
- Canberra	4
Delegates	**85**
- HDR Students	17
- CSIRO	18
- ANU	20
- Museum/Herbaria	31
- University	53

Along with the 12 invited speakers, 85 delegates attended our 2017 conference (Table 3.4). The conference program was comprised of 11 30-minute invited talks, 24 15-minute contributed talks and 14 5-minute lightning talks accompanied by posters. Seven travel grants of $750 AUD each for travel and other conference-related expenses were awarded to five Early Career Researchers: PhD students from the University of Wisconsin-Madison, University of Melbourne, University of Adelaide, Flinders University and University of Canberra.

After five years of successful conferences (Appendix), our focus for the coming years will be on smaller, more targeted workshops, still with some opportunity for information dissemination via lectures, short presentations and posters (similar to our April 2017 Museum Genomics in Practice workshop; Table 3.6).

Table 3.5 2017 Conference budget

Expenses	$	Income	$
Invited speaker travel	17449	CSIRO	30000
Invited speaker accommodation	5785	CBA	20000
ECR Travel Grants ($750)	3750	Registration - Full ($225)	9878
Catering	23210	Registration - Student ($100)	1692
Program printing	637		
Speakers'/organising committee/helpers' registration	4100		
TOTAL	**54930**	**TOTAL**	**61570**

3.3 Visiting scientists, training workshops and seminars

cba.anu.edu.au/opportunities/grants-funding/visiting-scientist-support
cba.anu.edu.au/opportunities/cba-grants-funding/training-support

A major objective of CBA is to enhance collaboration and training opportunities via external visitors who conduct a workshop and/or present a seminar during their visit to ANU and CSIRO. We encourage direct input from post docs and PhD students regarding the types of training activities they need to address their specific research requirements and interests.

CBA workshops and seminars are open to ANU and CSIRO staff and students and are also attended by students and researchers from the University of Canberra and interstate universities, museums and CSIRO sites. The workshops are funded by CBA (up to $5000), usually with a nominal registration fee that is used to contribute to catering costs and encourage attendance after registration.

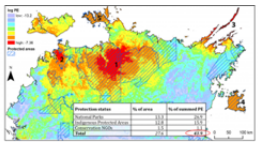
3.3.1 Training workshops

http://cba.anu.edu.au/news-events/cba-workshops

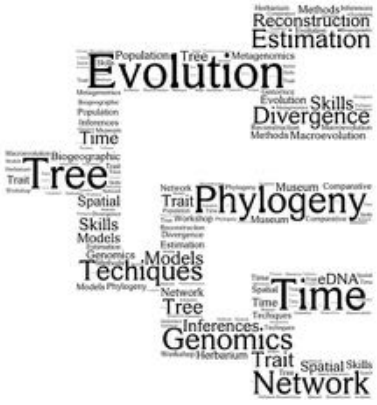
The CBA funded and organised two multi-day training workshops in 2016-17 (Table 3.6). In our workshop topics survey sent out to CBA members in December 2015 'museum genomics' was the most popular workshop topic. In response, the CBA hosted a three-day invitation-only workshop on 'Museum Genomics in Practice'. Our other workshop for 2016-17 was on 'Biodiversity in R: models and methods for spatial analysis', which was proposed, organised and presented by ECRs from the Research School of Biology and CSIRO Land & Water Flagship.

The CBA also supported a further two workshops in 2016-17 that were externally organized: 'Nanopore Sequencing Workshop' and 'Citizen Science and Biodiversity in the Age of Artificial Intelligence' (Table 3.6).

Table 3.6 2016-17 Workshops

21-23 Nov 2016	**Biodiversity in R: models and methods for spatial analysis** ECR-led CBA workshop (CBA Training Support) led and presented by Dan Rosauer (Research School of Biology, ANU) and Chris Ware and Karel Mokany (CSIRO Land & Water Flagship). CBA contributed $5K. 26 participants: ANU: 14, CSIRO: 2, UC: 2, Other: 8, HDR students: 15	
4-6 Apr 2017	**Museum Genomics in Practice** Invitation-only CBA workshop led by Craig Moritz (Research School of Biology, ANU). Invited speakers: Sonal Singhal (University of Michigan) and Lydia Smith (University of California Berkeley). CBA contributed $10K. 35 participants: ANU: 5, CSIRO: 8, UC: 1, Other: 8, HDR students: 2	
14-16 June 2017	**Nanopore Sequencing Workshop** CBA contributed $5K. Workshop organised and led by Benjamin Schwessinger, Megan McDonald, Steve Eichten, Norman Warthmann (Research School of Biology, ANU).	
31 Oct 2017	**Citizen Science and Biodiversity in the Age of Artificial Intelligence** CBA contributed $5K. External workshop held in Sydney at the Australian Museum organised and led by Andrew Robinson (QuestaGame) and Paul Flemons (Australian Museum).	

TEA Talks: Techniques in Evolutionary Analysis
cba.anu.edu.au/news-events/tea-talks

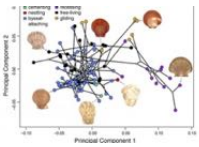
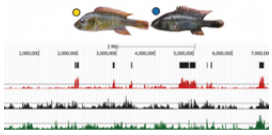


In November 2016, the CBA started a new workshop series that aimed to introduce a range of emerging concepts and techniques in evolutionary analysis. These short 'TEA Talks' (Techniques in Evolutionary Analysis) are targeted at ANU and CSIRO evolutionary biologists and ecologists (HDR students and researchers) who want to improve their understanding of current methods and analytical approaches in phylogenetics, bioinformatics and macroevolution. They were developed to complement the Research School of Biology's 'Techniques in Computational genomics (TIC)' meetings.

TEA Talks are typically held on the first Friday of each month at ANU from 12-2pm with free registration. Scientists from both ANU and CSIRO were approached to present, and continued invitations for presenters were made throughout the year to the CBA community, especially Early/Mid Career Researchers (EMCRs).

Our eventual aim for the TEA Talk program is for it to become a regular annual series of workshops, and possibly more formalised, such that participants will be able to obtain some sort of credit/recognition on completion, potentially as part of a course-work Masters program. TEA Talks also have the potential to provide valuable teaching experience to E/MCRs, along with reimbursement from the CBA for their work.

Table 3.7 2016-17 TEA Talks

04 Nov 2016	**Reading the story in DNA: the core principles of molecular phylogenetic inference** Lindell Bromham *Ecology & Evolution, Research School of Biology, ANU*	
02 Dec 2016	**Trees and networks in evolutionary analysis: to tree or not to tree?** Craig Moritz & Huw Ogilvie *Research School of Biology, ANU* Eric Stone *Centre for Genomics, Metabolomics and Bioinformatics, ANU*	
09 Feb 2017	**Estimating robust phylogenies: do's, don'ts, horror stories, and opportunities** Rob Lanfear *Ecology & Evolution, Research School of Biology, ANU*	
03 Mar 2017	**Beyond the tree: phylogenetic comparative methods for evolutionary inference of phenotypic data** Emma Sherratt & Ian Brennan *Ecology & Evolution, Research School of Biology, ANU*	
07 Apr 2017	**An introduction to population genomics** Sonal Singhal *University of Michigan*	
05 May 2017	**Model-based inference of environmental niches and niche evolution: fundamental and practical issues for discussion** Nick Matzke *Ecology & Evolution, Research School of Biology, ANU*	
04 Aug 2017	**Landscape adaptation to climate change** Justin Borevitz *Plant Sciences, Research School of Biology, ANU*	

3.3.2 Seminars

In 2016-17 we hosted four CBA seminars: cba.anu.edu.au/news-events/cba-seminars

Table 3.8 2016-17 CBA Seminars

10 Feb 2017	**Who, how much, how, when and where? Difficult questions on reticulate evolution in Cuscuta (dodders; Convolvulaceae)** Sasa Stefanovic *University of Toronto*	
15 Mar 2017	**On the maintenance of adaptive genetic variation to cope with environmental change: considerations from population genomics** Louis Bernatchez *Université Laval*	

31 Mar 2017 **Maximising the resilience of natural ecosystems in the Anthropocene**
Stephen Williams
James Cook University

21 Jul 2017 **Chromosomal hybrid zones and speciation in mice and shrews**
Jeremy Searle
Cornell University

3.4 Synthesis Groups

Since 2012, the Centre for Biodiversity Analysis has built an interactive and collaborative community across CSIRO and ANU and this is set to expand to include the University of Canberra from 2018 (see 3.6).
Looking forward, our key goals include:

- Increasing success with collaborative research proposals (ARC or other);
- Increasing demonstrable impact through translation of biodiversity research to policy and management; and
- Increasing the number of joint publications across institutions.

To this end, the CBA is planning to fund a small number (2-4) of CBA Synthesis Groups (SGs) per year at ~$15-25K per SG. This initiative will provide support for multiple meetings, and interim analyses, of small groups committed to generating;

- High impact syntheses and reviews of existing data or concepts;
- Collaborative grant proposals; or
- Policy and/or management outcomes via knowledge transfer amongst biodiversity scientists and policy makers and/or managers*.

CBA Synthesis Groups will need to incorporate evolutionary biology, genomic, bioinformatic and/or spatial modelling concepts, techniques and applications. They can focus on either blue-sky research questions or applied research outcomes (including stakeholder participation) - the CBA intends to support a mix of SGs across basic and translational research. For EMCR-driven proposals with strong emphasis at the interface of policy and biodiversity science, we will encourage applicants to also explore co-funding with new The Fenner School of Environment and Society Synthesis Program.

As with all CBA funding, the proposal will need to be co-led by scientists from at least two or more CBA partner institutions (i.e. ANU, CSIRO, UC) and have strong involvement of ECRs. The first round of Synthesis Groups is expected to be announced by the end of 2017 with proposals due early 2018.

3.5 Policy, outreach and communication

3.4.3 QuestaGame

portal.questagame.com

QuestaGame is a Canberra-based, now international, tech company that combines citizen science, biodiversity information economics and social gaming technologies to motivate and engage players to discover and learn about their local environments. Players, competing individually or in 'clan' groups, use a mobile phone app to take photos of living things. A collective 'bio-expertise engine' (which includes expert taxonomists in museums and herbaria to respected amateur natural historians) then identifies the sightings and players win points based on taxa, rarity, etc. These sightings

ultimately become citizen science data as the geocoded images and IDs are uploaded into the Atlas of Living Australia and the Global Biodiversity Information Facility where they are freely available for research and management, e.g. conservation, biosecurity.

QuestaGame developer Andrew Robinson approached CBA seeking collaborations with biologists, firstly for taxonomic expertise to assist with wildlife identifications; and secondly, working on potential research questions, such as the reliability and use of citizen-science observation data.

Recognising its value as a potential biodiversity outreach and education tool, the CBA has collaborated with QuestaGame by:

1. arranged ANU Visitor status for Andrew Robinson in 2017 to facilitate further collaborations with the CBA, such as research on the use and value of citizen-science data for both scientific purposes and community engagement and education.
2. Promoting QuestaGame internships (with stipend) that have developed to give students the opportunity to work with them.
3. Contributing $5K to a workshop on Citizen Science and Biodiversity in the Age of Artificial Intelligence, held in Sydney at the Australian Museum in October 2017.

3.6 CBA survey

An online survey was undertaken in November 2016 to assess CBA members' levels of engagement and views on the CBA's value and future to help with our bid for renew after June 2017.

The CBA has built an interactive research community across ~60 ANU and CSIRO labs in its first five years. A total of 46 CBA members answered the survey and their responses showed a high level of engagement with the Centre via conference, seminars, workshops and Ignition grants (Table 3.9). Significantly, 87% of respondents thought that the CBA should continue beyond its initial 5-year period.

In addition to the questions in Figure 3.9, the survey also asked:

- Any general comments on the CBA and its activities?
- If the CBA was funded beyond 2017 do you have any suggestions/comments for its future (e.g. structure, activities, etc.)?

The majority of responses emphasised the very strong support for the Ignition Grant scheme ("fantastic", excellent", "incredible", "unique", "effective", "amazing", "clever", "innovative catalyst"). The popularity of our workshop (and seminar and visiting scientist) programs was also confirmed, with several PhD students and ECRs commenting how valuable CBA training workshops had been for their research. They also stated that they hoped these would continue and be expanded to cover other topic areas.

The other most common comment was how valuable the new CBA-facilitated interactions, and the collaborative research that developed from them were, and the hope that this continued to be the focus of the CBA. There were also comments on broadening input into direction and investment of the CBA and its activities from its members, including interactions across schools (ANU) and divisions (CSIRO). The value of co-supervised students was also indicated. There were also several requests that our events be made more available to CSIRO members outside of Canberra via recordings and streaming, and several comments on expanding our communication, policy engagement and outreach, e.g. CEED, Threatened Species Recovery Hub, National Science Week.

Table 3.9 CBA member survey results (Nov 2016).

Institution

46 out of 46 people answered this question

1	ANU	31 / 67%
2	CSIRO	12 / 26%
3	Other	3 / 7%

Since its establishment in 2012, approximately how many years have you been involved with the CBA?

46 out of 46 people answered this question

1	4+	17 / 37%
2	3	12 / 26%
3	2	11 / 24%
4	1 or less	6 / 13%

CBA conferences

46 out of 46 people answered this question

1	Attended: 1	16 / 35%
2	Presented: 1	15 / 33%
3	Attended: 2	9 / 20%
4	Attended: 4	9 / 20%
5	Attended: 3	7 / 15%
6	Presented: 0	6 / 13%
7	Attended: 0	5 / 11%
8	Presented: 2	4 / 9%
9	Presented: 3	1 / 2%
10	Presented: 4	1 / 2%

Have you applied for a CBA Ignition Grant/s?

46 out of 46 people answered this question

1	No	23 / 50%
2	Yes, my proposal was successful	21 / 46%
3	Yes, but my proposal did not receive funding	2 / 4%

Do you think the CBA should continue beyond its original 5 year period?

45 out of 46 people answered this question

1	Yes	39 / 87%
2	No	4 / 9%
3	Not sure	2 / 4%

Position

46 out of 46 people answered this question

1	Research scientist	19 / 41%
2	Post doc	13 / 28%
3	PhD student	11 / 24%
4	Honours student	2 / 4%
5	Other	1 / 2%

CBA workshops

46 out of 46 people answered this question

1	Attended: 1-2	24 / 52%
2	Attended: 3-4	12 / 26%
3	Presented: 1-2	8 / 17%
4	Presented: 0	7 / 15%
5	Attended: 0	6 / 13%
6	Attended: more than 5	3 / 7%
7	Presented: 3-4	0 / 0%
8	Presented: more than 5	0 / 0%

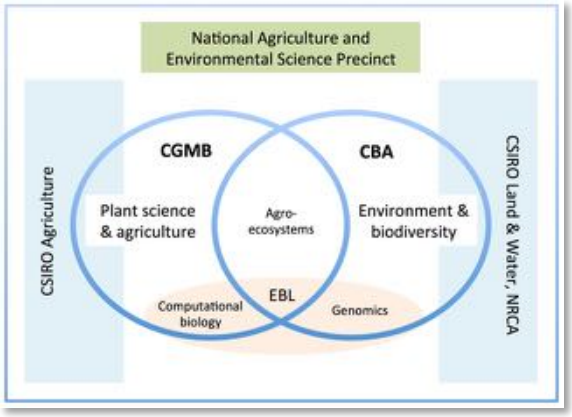
CBA seminars/symposia

46 out of 46 people answered this question

1	Attended: 1-2	16 / 35%
2	Attended: more than 5	12 / 26%
3	Attended: 3-4	11 / 24%
4	Presented: 0	7 / 15%
5	Attended: 0	6 / 13%
6	Presented: 1-2	6 / 13%
7	Presented: 3-4	1 / 2%
8	Presented: more than 5	0 / 0%

3.7 CBA Mk 2

During 2016-17 Craig Moritz developed a funding proposal for the renewal of the CBA, highlighting the success of the CBA over the past five years. The Centre has used its modest resources to develop collaborations via visiting scientists, seminars and the delivery of 13 ECR-focused training workshops, four annual conferences, and seed funding of 30 Ignition grants, with 107 researchers and students involved in an Ignition project to date.



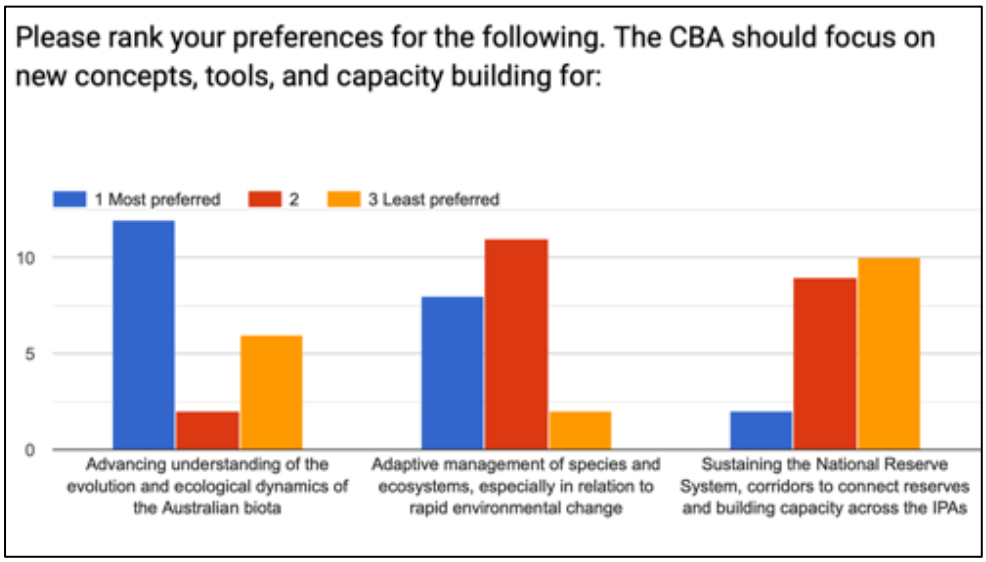
The proposal also outlined the future role the CBA could play in the National Agriculture and Environment Science Precinct. The CBA would represent a hub for 'Environment'-oriented research and training within the National Agriculture and Environment Science Precinct. Support was requested from ANU's Research School of Biology, College of Science and Medicine and DVC-Research, and CSIRO's Collections and Land and Water.

In June 2017, contributions were confirmed from ANU (RSB lab leaders, CMBE and DVCR = $200K) and CSIRO (National Research Collections = $100K) and the CBA was renewed for a further three years.

Over 2017-20 we will continue to build on the activities of the last five years and, depending on the interests of CBA members and participants, provide opportunities to broaden the Centre's focus to include wider applications of evolutionary biology. New activities will include funding for cross-disciplinary synthesis working groups and targeted recruitment of joint ANU-CSIRO Honours and PhD students, with the aim, along with continuing activities, of further strengthening interactions across ANU and CSIRO via the National Agriculture and Environmental Science Precinct (NAESP). In our next iteration, it is intended to broaden the scope of the CBA to include components of the Institute for Applied Ecology at UC and stronger connections with local industry (e.g. DArT; Questagame). We will also aim to build a stronger connection with the Fenner School of Environment and Society at ANU in relation to ecosystem ecology/management and translation of ecological/evolutionary science to policy.

On confirmation of our renewal, we asked our CBA community to complete a short questionnaire to help to maximise its value, impact and potential for persistence (in some form) going forwards, and focus and prioritise allocation of available resources. One way of doing this is to align our science with strong impact to community and government, and important strategic areas in our partners (CSIRO's Environomics FSP, ANU's Strategic Plan, etc.). There were mixed responses to engagement with policy and management, but overall fairly strong support for this direction, alongside a strong focus on the evolution and ecology of Australian biota.

There was also strong continuing support of Ignition grants, and strong interest in the newly proposed Synthesis Groups. Conferences, had the lowest score for potential engagement compared to the other activities. There was also strong continuing support for our training workshops with many topic suggestions.

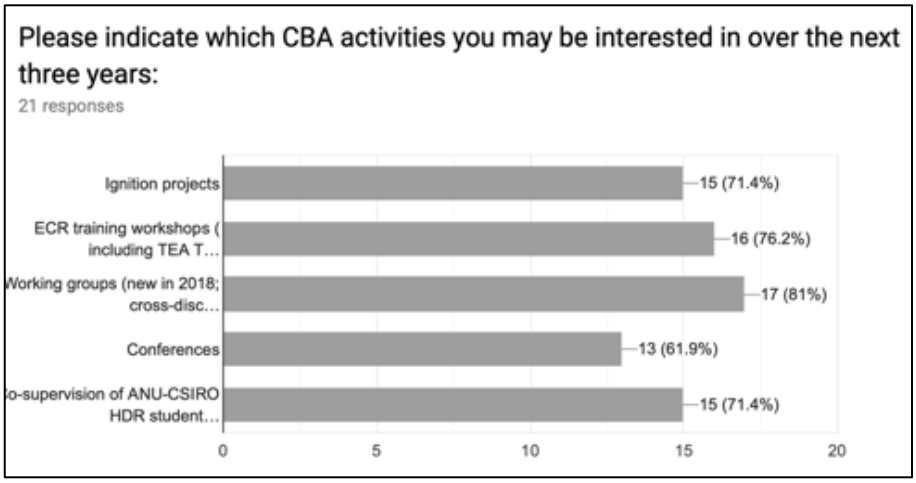


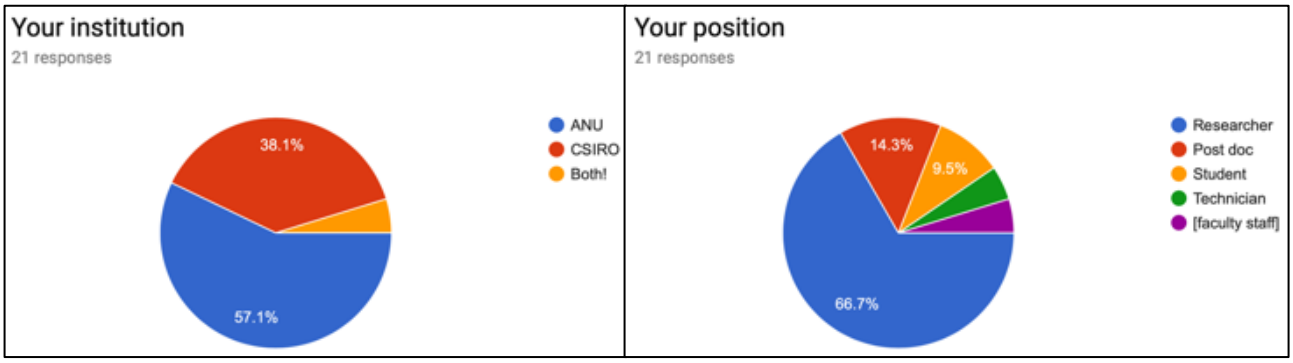
Other suggested focus areas for the CBA and/or comments:

- Biosecurity and invasive species impacts.
- Just a comment on the above: I did not see the CBA's aim as community/government impact - this is a requirement of so many other programs, so why not use the CBA for fundamental research?
- Broader connections between scientists and policy makers. For what it's worth, I feel like the first point (advancing understanding...) is something that we should expect RSB/Fenner etc. to do themselves, without devoting CBA resources to it.
- Collection genomics.
- Advancing understanding of the co-evolution of landscapes and biota, linking geo- and biosciences.
- Each of these three are great objectives, and relevant for the CBA. "Evolution and ecological dynamics" should remain the core, but building capacity and reputation related to applied conservation solutions would be a great goal too.
- There may be interest in extending to considering an additional focus on ecosystem processes, structure function, and biodiversity.
- All of the objectives listed above are good and I don't have a strong preference. However, better integration of genetics/evolutionary biology into conservation and land management (esp. in Australia) is an area in which the CBA could make a substantial and new contribution.

We want to re-launch our ECR training workshop program. Do you have any topic suggestions?

- Fostering interdisciplinary research.
- Managing teams, dealing with PC2/DAWR regulations/permits, grant writing, pitching research.
- Exon capture pipeline Population genomics Using the software, ANGSD.
- Phylogenetics. I'm about to hire a good postdoc in this area who wrote one of the best bits of software. He could almost certainly run a very good workshop and it would be great to do it through the CBA.
- A workshop that advances researchers ideas of how policy is formed. Where are the opportunities to have input and to provide new ideas to influence what ideas are put to Government. I liked very much the policy conference that CBA ran last year...we have no shortage of ideas and data but translating that into implementation programmes has always been a bottleneck for researchers and the next generation might hopefully do it better than we have!
- Presence and presentation - how to give your spoken message impact. For example: https://www.business.unsw.edu.au/our-people/josephineo'reilly.





4. Summary of discoveries made, or other achievements, including Project IPR, other IPR and Confidential information.

4.1 Publications from CBA project funding

- Supple, M., et al. In press. Landscape genomic prediction for restoration of a Eucalyptus foundation species under climate change. (Project: How local is local? Landscape genomics in Yellow box)
- McElroy, K., et al. 2017. Mitogenomic and nuclear diversity in the Mulga Parrot of the Australian arid zone: cryptic subspecies and tests for selection. Emu - Austral Ornithology (Project: Bill adaptation in parrots: finding loci involved in surface area increases by integrating morphometrics with Next Gen Sequencing)
- Schmidt-Lebuhn, et al. 2017. Species trees from consensus single nucleotide polymorphism (SNP) data: Testing phylogenetic approaches with simulated and empirical data. Molecular Phylogenetics and Evolution 116: 192-201 (Project: Evolutionary processes in Billy buttons)
- Bourke, G., et al. 2017. Systematics of a small Gehyra (Squamata: Gekkonidae) from the Einasleigh Uplands, Queensland: description of a new range restricted species. Zootaxa 4231(1):0850-099 (Project: Species discovery and refugia in the monsoonal tropics)
- Gardner, J., et al. 2016 Spatial variation in avian bill size is associated with humidity in summer among Australian passerines. Climate Change Responses 3:11 (Project: Effects of climate change on avian morphology)
- Ens, E., et al. 2016. Putting indigenous conservation policy into practice delivers biodiversity and cultural benefits. Biodiversity and Conservation 25: 2889 (Project: ALA Two-way Indigenous Engagement Case Study)
- Louys, J., et al. 2014. Rewilding the tropics, and other conservation translocations strategies in the tropical Asia-Pacific region. Ecology and Evolution 4(22): 4380-4398 (Project: Palaeoecological indicators of biodiversity change through time)

4.2 Review of the Research School of Biology (RSB) at ANU

In December 2017, the Research School of Biology underwent a school-wide review by Professor Elizabeth Hartland (UMelb), Professor Scott Edwards (Harvard), and Professor Richard Newcomb (University of Auckland) with a view to advising the School on how it could build on and improve its research and educational programs, its human resource profile, its governance and management, and its sustainability.

In its praise of the Division of Ecology and Evolution as "one of the strongest in the country with a good research focus and is widely recognized as one of the leading research groupings internationally", the School Review Panel also made particular note of the CBA several times in its report:

- "The Centre for Biodiversity Analysis (CBA) is one hub of activity that serves as a forum for scholarly exchange both globally and, with its collaboration with CSIRO in the wider Australian community."
- "Centres, such as the CBA and the two CoEs in Plant Sciences, have clearly brought prominence and dynamism to RSB. The activities fostered by these centres, including workshops, in-house funding, symposia and other sorts of collaborative activities, serve as a model for desired activities in the RSB generally. Targeting areas of advanced training for HDRs, including ECR-led training workshops, will help develop future degree programs (such as Master's programs) but help maintain the high level of research opportunities so as to attract the best students nationally and internationally. Centres have been important in providing RSB revenue for new postdocs and students from within and outside of Australia. Understanding what the future Centres for RSB will be and making sure the research profiles of the Division place them well for these Centres will be an important activity going forward."

The Review also highlighted the importance of interacting with CSIRO, particularly the strategic advantage of CSIRO's co-location and the new 'Environomics' Future Science Platform (see section 5.1), opportunities that the CBA does, and will continue to, take advantage of.

5. Interactions and developing interactions with third parties.

5.1 CSIRO 'Environomics' Future Science Platform

In June 2016, the bid for a **CSIRO Future Sciences Platform on Environomics – an 'omics-based platform for next-generation environmental science**, led by Andrew Young (CSIRO, Director NRCA) was successful, with indicative funding of ~$4.5M over 2-3 years. CBA Director Craig Moritz led discussions with ANU to support the bid.

In August 2017, we welcomed Environomics FSP Leader Oliver Berry to our Liaison Committee as our second CSIRO member. All FSP teams across CSIRO (nationally) have been invited to be part of the CBA, and have access to our training workshops, funding opportunities, etc.

In early 2018 the CBA intends to advertise a postdoctoral position, co-funded with the Environomics FSP, to drive the development of a next-generation biodiversity informatics platform for integrated analyses and visualisation of environmental and species data (occurrences, sequences, and phenotypes) in a phylogenetic context. The appointee will work closely with scientists in CSIRO and ANU and staff at the Atlas of Living Australia to create a platform for analysis, modelling, and visualisation of data to enable assessments of genetic, phylogenetic, and functional diversity across time and space, and to assess the evolution of species traits and distributions.

6. Financial statement

A full statement of Income and Expenditure for 1 July 2016 - 30 June 2017, prepared by ANU Finance, is attached to this report.

Table 6.1 Budget summary. The core CBA budget is $200K/year, shared equally by CSIRO and ANU. Budget allocations (Items) are set annually by the CBA Liaison Committee.

Item	Yr 4 (15-16) proposed	Yr 4 actual	Yr 5 (16-17)	Notes for Yr5
Coordinator: C Stephens	60	50	65	
Outreach & promotion	15	0	30	Assistance (salary) to put in action recommendations from 2016 Policy Workshop.
Projects	80	80	90	Up to 9 Ignition grants
Hardware & equipment	10	15	7	Contributions to acoustic liquid handler (SIEF) ($5K) and real-time PCR machine (RSB RSB Small Research Equipment Round) ($2K)
Bioinformatics support: J Bragg (24%)	30	30	0	J Bragg finished at ANU
Annual symposium & training workshops	50	50	40	2017 Conference (co-funded with CSIRO) + $20K for new workshops
Visiting fellowships	15	0	5	
Carryforward	-60	-60	-35	
Total	**200**	**165**	**202**	
Income (CSIRO/ANU)	**200**	**200**	**200**	

Appendix

Summary of CBA activities: August 2012-October 2017

Joint ANU-CSIRO Ignition Projects

1. **Uncovering the hare microbiome – implications for invasive lagomorph management** (Student project) John Rathjen, Benjamin Schwessinger, Louis Ranjard (RSB, ANU), Robyn Hall (CSIRO Health and Biosecurity) (July 2017).
2. **The untold story of underground communities: fungi and soil seed banks in Mountain Ash forests** Elle Bowd (PhD student), David Lindenmayer, Sam Banks (Fenner ANU), Andrew Bissett (NRCA, CSIRO) Tom May (The Royal Botanical Gardens, Victoria) (July 2017).
3. **Biodiversity change: A risk factor for human health?** Aparna Lal (National Centre for Epidemiology and Population Health, ANU), Karel Mokany (CSIRO Land and Water) (July 2017).
4. **Phylogeny of the longhorn beetle genus Rhytiphora (Coleoptera: Cerambycidae).** Lauren Ashman (PhD student), David Rowell (RSB, ANU), Adam Slipinski, Andreas Zwick (ANIC, CSIRO) (July 2017).
5. **Understanding biological invasions: assessing the biosecurity threat of the pink bollworm to Northern Australia** Angela McGaughran, Rob Lanfear (RSB ANU), Tom Walsh (CSIRO Land & Water) (July 2017).
6. **The landscape genomics of a dryland river keystone species, Eucalyptus coolabah: the influence of hydrochory on landscape genetic structure** Jake Gillen (Fenner, ANU), David Bush, (Australian Tree Seed Centre, CSIRO) (July 2017).
7. **Tackling the unknown – a next-generation phylogenetics approach to explore the immense diversity of Australian thynnine wasps (Tiphiidae: Thynninae)** Thomas Semple (PhD student RSB, ANU), Rod Peakall (RSB, ANU), Andreas Zwick (CSIRO NRCA) (July 2016).
8. **Genomic diversity in Australian palms** Bee Gunn (RSB, ANU), Sarah Mathews (NRCA, CSIRO) (July 2016).
9. **Biogeography of sex reversal and the effects of climate change on reptile sex determination** Clare Holleley (CSIRO NRCA), Kerensa McElroy (CSIRO NRCA), Dan Rosauer (RSB, ANU), Craig Moritz (RSB, ANU), Arthur Georges (IAE, U Canberra) (July 2016).
10. **Characterizing the evolutionary and ecological diversity of invertebrates in the Monsoonal vine thickets of the Kimberley** Russell Dinnage (RSB, ANU), Marcel Cardillo (RSB, ANU), Gavin Huttley (RSB, ANU), Owain Edwards (CSIRO Land & Water) (July 2016).
11. **A winning combination? Could seed dormancy and polyploidy be beneficial in a warmer, drier climate?** (Hons Project) Lydia Guja (NRCA, CSIRO), Robert Godfree (NRCA, CSIRO), Adrienne Nicotra (RSB, ANU), Amelia Stevens (RSB, ANU Hons student) (Sept 2015).
12. **An exome capture system for phylogenetic and evolutionary studies in the hyperdiverse orchid tribe Diurideae (Orchidoideae)** Katharina Schulte (NRCA, CSIRO), Mark Clements (NRCA, CSIRO), Lars Nauheimer (NRCA, CSIRO), Rod Peakall (RSB, ANU), Celeste Linde (RSB, ANU), Ryan Phillips (RSB, ANU) (Sept 2015).
13. **Investigating the effects of diversity, distribution and chytrid load on Uperoleia frog skin microbial communities** Matt Morgan (Land & Water, CSIRO), Maxine Piggott (RSB, ANU), Renee Catullo (RSB, ANU) (Sept 2015).
14. **Bill adaptation in parrots: finding loci involved in surface area increases by integrating morphometrics with NGS** (Hons Project) Kerensa McElroy (NRCA, CSIRO), Loeske Kruuk (RSB, ANU), Janet Gardner (RSB, ANU), Keira Beattie (RSB, ANU Hons student) (Sept 2015).
15. **Can adaptation in 'ecosystem engineers' drive fire regime feedbacks?** Annabel Smith (Fenner), Justin Borevitz (RSB, ANU), Shannon Dillon (Agriculture, CSIRO) (Sept 2015).
16. **Curating spatial data to understand patterns and processes shaping biodiversity in New Guinea** Paul Oliver (RSB, ANU), Dan Rosauer (RSB, ANU), Eric Rittmeyer (RSB, ANU), Kristin Williams (CSIRO Land & Water), Leo Joseph (ANWC, CSIRO).
17. **Environmental Drivers of Acacia-Associated Symbiotic Microbe Diversity** Russell Dinnage (RSB, ANU), Marcel Cardillo (RSB, ANU), Anna Simonsen (Land & Water CSIRO), Suzanne Prober (Land & Water CSIRO), Luke Barrett (Land & Water CSIRO), Pete Thrall (Land & Water CSIRO) (Sept 2015).
18. **Linking genomic data to spatial biodiversity data in the Atlas of Living Australia** Caroline Chong (RSB, ANU), Justin Borevitz (RSB, ANU), Lindell Bromham (RSB, ANU), Rebecca Pirzl (NCRA, CSIRO), John La Salle (NCRA, CSIRO) (Sept 2015).
19. **Genetic characterisation of formalin preserved fish tissue** Sharon Appleyard (NCRA, CSIRO) and Maxine Piggott (RSB, ANU) (Mar 2015).

20. **Developing new methods for using distribution data to identify taxa that can tolerate extreme conditions** Xia Hua (RSB, ANU), Lindell Bromham (RSB, ANU), Marcel Cardillo (RSB, ANU) and ALA (NCRA, CSIRO) (Mar 2015).
21. **Effects of climate change on avian morphology** Janet Gardner (RSB, ANU), Loeske Kruuk (RSB, ANU) and Leo Joseph (NRCS, CSIRO) (Mar 2015).
22. **Genetic and demographic impacts of contemporary disturbance regimes in Mountain Ash forests** Brenton von Takach Dukai (Fenner, ANU PhD student), Sam Banks (Fenner, ANU) and Shannon Dillon (Agriculture, CSIRO) (Mar 2015).
23. **Eucalyptus genomics project** Linda Broadhurst (NRCS, CSIRO), David Bush (NRCS, CSIRO), Brendan Lepschi (NRCS, CSIRO), Justin Borevitz (RSB, ANU), Norman Warthmann (RSB, ANU), Megan Supple (RSB, ANU) and Jason Bragg (RSB, ANU) (Jun 2014).
24. **Bringing next generation approaches to conservation genomics using museum collections – Rock wallaby museum skinomics** Sally Potter (RSB, ANU), Maxine Piggott (RSB, ANU), Jason Bragg (RSB, ANU), Matthew Morgan (Land & Water, CSIRO), Leo Joseph (NRCA, CSIRO) (Jun 2014).
25. **Collections-based landscape genomics: Red-browed finches as a test case** Kerensa McElroy (NRCA, CSIRO), Norman Warthmann (RSB, ANU) (Jun 2014).
26. **Penguin ectoparasites of the Southern Hemisphere** Katherine Moon (Fenner, ANU PhD student), Ceridwen Fraser (Fenner, ANU), Bruce Halliday (NRCA, CSIRO) (Jun 2014).
27. **Genome skimming with degraded DNA from herbarium specimens** Alexander Schmidt-Lebuhn (NRCA, CSIRO), Adrienne Nicotra (RSB, ANU) (Jun 2014).
28. **Molecular phylogeny of *Helicoverpa* from museum specimens** Andreas Zwick (NRCA, CSIRO), David Yeates (NRCA, CSIRO), Tom Walsh (NRCA, CSIRO), Karl Gordon (NRCA, CSIRO), Craig Moritz (RSB, ANU), Dave Rowell (RSB, ANU) (Jun 2014).
29. **Palaeoecological indicators of biodiversity change through time** Simon Haberle (Culture, History & Language, ANU), Geoff Hope (Culture, History & Language, ANU), Dan Rosauer (RSB, ANU), Kristen Williams (Land & Water, CSIRO) (Aug 2013).
30. **Future ecosystem states: linking ecophysiological cues and thresholds to climatic regimes, variability and weather extremes** Kristen Williams (Land & Water, CSIRO), Simon Ferrier (Land & Water, CSIRO), Craig Moritz (RSB, ANU) (Jun 2013).
31. **A curation community for coral environmental genomics** Alexie Papanicolaou (Land & Water, CSIRO), Owain Edwards (Land & Water, CSIRO), Sylvain Forêt (RSB, ANU) (Jun 2013).
32. **A test of the power of genotype by sequencing (GBS) for delimiting species boundaries among incipient species of Australian orchids** Rod Peakall (RSB, ANU), Celeste Linde (RSB, ANU), Mark Clements (NRCA, CSIRO) (Jun 2013).
33. **Evolutionary processes in Billy buttons** Alexander Schmidt-Lebuhn (NRCA, CSIRO), Justin Borevitz (RSB, ANU) (Jun 2013).
34. **Species discovery and refugia in the monsoonal tropics** Craig Moritz (RSB, ANU), Scott Keogh (RSB, ANU), Justin Perry (Land & Water, CSIRO), Eric Vanderduys (Land & Water, CSIRO), Simon Ferrier (Land & Water, CSIRO) (Oct 2012).
35. **Hybrid history: deep sequencing of the Tasmanian blue gum** Carsten Kulheim (RSB, ANU), Joe Miller (NRCA, CSIRO) (Oct 2012).
36. **How local is local? Landscape genomics in Yellow box** Justin Borevitz (RSB, ANU), Linda Broadhurst (NRCA, CSIRO) (Oct 2012).

Publications from CBA-funded projects

1. Supple, M., et al. In press. **Landscape genomic prediction for restoration of a Eucalyptus foundation species under climate change**. (Project: How local is local? Landscape genomics in Yellow box).
2. McElroy, K., et al. 2017. **Mitogenomic and nuclear diversity in the Mulga Parrot of the Australian arid zone: cryptic subspecies and tests for selection**. *Emu - Austral Ornithology* (Project: Bill adaptation in parrots: finding loci involved in surface area increases by integrating morphometrics with Next Gen Sequencing).
3. Schmidt-Lebuhn, et al. 2017. **Species trees from consensus single nucleotide polymorphism (SNP) data: Testing phylogenetic approaches with simulated and empirical data**. *Molecular Phylogenetics and Evolution* 116: 192-201 (Project: Evolutionary processes in Billy buttons).
4. Bourke, G., et al. 2017. **Systematics of a small Gehyra (Squamata: Gekkonidae) from the Einasleigh Uplands, Queensland: description of a new range restricted species**. *Zootaxa* 4231(1):0850-099 (Project: Species discovery and refugia in the monsoonal tropics).
5. Gardner, J., et al. 2016 **Spatial variation in avian bill size is associated with humidity in summer among Australian passerines**. *Climate Change Responses* 3:11 (Project: Effects of climate change on avian morphology).
6. Ens, E., et al. 2016. **Putting indigenous conservation policy into practice delivers biodiversity and cultural benefits**. *Biodiversity and Conservation* 25: 2889 (Project: ALA Two-way Indigenous Engagement Case Study).]
7. Louys, J., et al. 2014. **Rewilding the tropics, and other conservation translocations strategies in the tropical Asia-Pacific region.** *Ecology and Evolution* 4(22): 4380-4398 (Project: Palaeoecological indicators of biodiversity change through time).

Conferences

1. **Genomics and Collections: Adaptation to Macroevolution** (Sept 2017)
2. **The interface of evolutionary biology and policy impact** (Sept 2016)
3. **Species delimitation in the age of genomics** (Apr 2015)
4. **Understanding biodiversity dynamics using diverse data sources** (Apr 2014)
5. **Biodiversity genomics** (Apr 2013)

Workshops

1. **Museum genomics in practice** (Apr 2017)
2. Dan Rosauer (ANU), Chris Ware, Karel Mokany, Andrew Hoskins, Tom Harwood and Simon Ferrier (CSIRO) **Biodiversity in R: models and methods for spatial analysis** (Nov 2016)
3. Scott Edwards (Harvard University) **Phylogenomic analyses using the multispecies coalescent model** (Dec 2015).
4. Gurutzeta Guillera-Arroita & José J. Lahoz-Monfort (School of BioSciences, Univ. Melbourne) **Hierarchical occupancy-detection modeling** (Nov 2015).
5. Alexander Xue (City Univ. New York) **Demographic inference for comparative phylogeograpy using Next-Gen sequence data** (Sept 2015).
6. Olivier Loudet (INRA Versailles) & Justin Borevitz (ANU) **Genomic and phenomics tools to identify the genetic basis underlying natural variation and adaptation** (June 2015).
7. Oliver Niehuis (Zoologisches Forschungsmuseum Alexander Koenig) **DNA target enrichment in phylogenomics - molecular and bioinformatic principles** (Oct 2014).
8. Dan Rabosky (Univ. Michigan) **Computational macroevolution and phylogenetic comparative methods** (Sept 2014).
9. Matteo Fumagalli (UC Berkeley), Anders Goncalves da Silva (Monash), Rose Andrew (UNE), Justin Borevitz (ANU) & Kevin Leempoel (École Polytechnique Fédérale de Lausanne) **Population and landscape genomics** (Mar 2014).
10. Australian Bioinformatics Network **R Bootcamp** (Oct 2013).
11. Alexei Drummond (Univ. Auckland) **Phylogenomics using BEAST2** (July 2013).
12. Rod Peakall (ANU) & Peter Smouse (Rutgers Univ.) **GenAlEx: Genetic analysis for population studies** (July 2013).
13. Steve Stones-Havas (Biomatters) **Geneious** (Apr 2013).
14. Joseph Heled (Univ. Auckland) **BEAST2** (Apr 2013).

TEA Talks

1. Justin Borevitz (ANU) **Landscape adaptation to climate change** (Aug 2017).
2. Nick Matzke (ANU) **Model-based inference of environmental niches and niche evolution: fundamental and practical issues for discussion** (May 2017).
3. Sonal Singhal (University of Michigan) **An introduction to population genomics** (Apr 2017).
4. Emma Sherratt and Ian Brennan (ANU) **Beyond the tree: phylogenetic comparative methods for evolutionary inference of phenotypic data** (Mar 2017).
5. Rob Lanfear (ANU) **Estimating robust phylogenies: do's, don'ts, horror stories, and opportunities** (Feb 2017).
6. Craig Moritz, Huw Ogilvie and Eric Stone (ANU) **Trees and networks in evolutionary analysis: to tree or not to tree?** (Dec 2016).
7. Lindell Bromham (ANU) **Reading the story in DNA: the core principles of molecular phylogenetic inference** (Nov 2016).

Seminars & symposia

1. Jeremy Searle (Cornell University) **Chromosomal hybrid zones and speciation in mice and shrews** (Jul 2017)
2. Stephen Williams (Centre for Tropical Biodiversity & Climate Change, James Cook University) **Maximising the resilience of natural ecosystems in the Anthropocene** (Mar 2017)
3. Louis Bernatchez (Université Laval) **On the maintenance of adaptive genetic variation to cope with environmental change: considerations from population genomics** (Mar 2017)
4. Sasa Stefanovic (University of Toronto) **Who, how much, how, when and where? Difficult questions on reticulate evolution in Cuscuta (dodders; Convolvulaceae)** (Feb 2017)
5. Hugh Possingham (Univ. of Queensland) **Why monitor or do research in conservation?** (July 2016).
6. Hilary Martin (Wellcome Trust Centre for Human Genetics, Oxford) **Insights into sex chromosome evolution and population dynamics and history from whole-genome sequencing of platypus** (July 2016).
7. **Ignition Project Symposium** (June 2016).
8. Andrew Robinson (Co-Founder, QuestaGame) **QuestaGame: How a Multiplayer Mobile Game Can Raise the Value of Biodiversity Knowledge** (April 2016).
9. Owain Edwards (Environmental Genomics, CSIRO Land & Water) **Should gene drives be considered for applications in biodiversity and conservation?** (March, 2016).
10. Rick Harrison (Ecology and Evolutionary Biology, Cornell University) **Differential Introgression and the "Genic View" of Species** (Feb, 2016).
11. Vicki Funk (Smithsonian) **Origin and patterns of evolution in Pacific Compositae (Asteraceae)** (December 2015).
12. John Woinarski (Charles Darwin University) and Barry Traill (Pew Charitable Trusts) **Making a Modern Outback - the future of nature and people in remote Australia** (Sept 2015).
13. Emilie-Jane Ens (Macquarie Univ.) **ALA Two-way Indigenous Engagement Case Study** (Mar 2015).
14. Jérôme Chave (Evolution et Diversité Biologique, Université Paul Sabatier) I**n-situ diversification versus migration patterns in the assembly of Neotropical plant lineages** (Mar 2015).
15. Matthew Barrett (Botanic Gardens and Parks Authority & UWA) **Diversity and diversification of the Kimberley flora** (Jun 2014).
16. Eddie Holmes (Univ. Sydney) **The Greatest Experiment in Evolution: Viral Biocontrol of Rabbits** (Mar 2014).
17. Alan Andersen (CSIRO) **Historical biogeography shapes community ecology** (Feb 2014).
18. Alexei Drummond (Univ. Auckland) **Developing Darwin's computer** (Jul 2013).

New funding and collaborations

1. **CSIRO 'Environomics' Future Science Platform (FSP)** ($5.5M) (September 2016).
2. **Bioplatforms Australia Oz Mammal Genome Initiative** ($1.1M) (July 2016).
3. **ARC Discovery Grant Evolution at extremes: Macroevolutionary responses to harsh environments** ($378K) (October 2015).

4. **Science and Industry Endowment Fund (SIEF)** ($10M) (December 2014).
5. **ARC Linkage Grant - Landscape restoration genomics for climate adaptation in eucalyptus foundation species** ($375K) (June 2013).
6. **QuestaGame**
7. **Pew Charitable Trusts**

Policy engagemnt, outreach and communication

1. Editorial in CEED's Decision Point: **Evolutionary biology – what is it good for?** (Oct 2016)
2. Annual Conference: **The interface of evolutionary biology and policy impact** (Sept 2016).
3. Public seminar: **Big questions in biology: Australia's biodiversity, its past, present and future** Craig Moritz (Aug 2016).
4. Article in the Research School of Biology's **Alumni newsletter** (March 2016)
5. Conference session: **Public communication and policy issues associated with species delimitation** (Apr 2015).
6. Conversation article: **Remote Indigenous communities are vital for our fragile ecosystems** Craig Moritz, Emilie-Jane Ens and Jon Altman (Mar 2015).
7. Project: **Atlas of Living Australia Two-way Indigenous Engagement Case Study** (2014-15).
8. Evening science discussion: **Current practices and future goals for conservation planning based on the increasing availability of new, large-scale biodiversity data** (Apr 2014 conference).
9. Conference workshop: **The contribution of biodiversity genomics to policy and management** (Apr 2013).