Australian National University

CSIRO

Centre for Biodiversity Analysis

cba.anu.edu.au

2014-15 Annual report

October 2015

1. Director's summary

This has been another very active and productive year for the Centre for Biodiversity Analysis (CBA). As detailed below, we ran an intellectually stimulating conference on "Species delimitation in the age of genomics". This conference considered emerging concepts, methods and revolutionary insights arising from applying new genomics capabilities to our native biota, and implications for the science of systematics, conservation policy, and our "social contract" with the public.

We organised and ran a series of skills-based workshops on technical and analytical methods in biodiversity genomics. These, along with the Ignition Grants, are increasingly proposed and led by postdocs in CBA labs, which is a very positive development.

In the current year, we awarded 11 Ignition grants to stimulate ANU-CSIRO collaboration. These spanned an impressive range of questions and methods in biodiversity science, as we would hope for given the breadth and strength of ANU and CSIRO researchers.

A further focus for the year was establishing a new ANU-CSIRO Ecogenomics and Bioinformatics Laboratory (EBL) with funding from the Science and Industry Endowment Fund (SIEF). This facility will bring together spatial ecologists, computer biologists and biodiversity genomicists to develop new ways of accessing and interpreting genome-scale data across the tree of life and from populations to ecosystems. It will also provide training opportunities across this spectrum to enable non-specialists (e.g. ecologists, evolutionary biologists) to exploit these rapidly evolving capabilities. We expect that the EBL will commence operations in the first half of 2016.

Since the establishment of the CBA in mid 2012, I think we can be quietly satisfied with the positive impact of the Centre on the quality and connectivity of biodiversity science and its applications across the two institutions. But there are also important goals still to be met:

- Increasing the number of co-supervised students across CSIRO and ANU, and
- Increasing engagement around evolutionary biology and its applications with policy makers and the public.

On the last topic, we have made some good progress in the past year, both in public communication, via our web site, and direct interactions with government and NGOs. This, along with fostering collaborative supervision, will be a focus in the coming year.

Finally, and once again, I thank our wonderful CBA coordinator, Claire Stephens, for her sterling efforts in translating our aspirations into actions.

Craig Moritz
CBA Director

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 (50% position, Mon-Wed).
- 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 - Division of Plant Sciences, Research School of Biology.
  - Scott Keogh - Division of Evolution, Ecology and Genetics, Research School of Biology.
- **CSIRO**
  - Andrew Young - National Research Collections Australia, Facilities and Collections.
  - Andy Sheppard (2012-Nov 2013) - Biosecurity Flagship.
  - Owain Edwards (Dec 2013-July 2014) - Ecosystems Sciences.
  - Ian Cresswell (Aug 2014-current) - Biodiversity, Ecosystem Knowledge and Services, Land and Water Flagship.

2.3 CBA membership

- cba.anu.edu.au/about-us/people
- Currently 50 lab leaders and research scientists are involved with the CBA.
- 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 and spatial ecology into the discovery, understanding and protection of Australia's biodiversity:

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

  ANU
  - Evolution, Ecology & Genetics (EEG) 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.

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 the ANU Major Equipment Committee (MEC) proposal (awarded) 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, and 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 Jason Bragg (jason.bragg@anu.edu.au) for details on capabilities and access (2013 - $30K).

2.6 CBA activities

Further details of 2014-15 activities below (Section 3); full details of all CBA activities are listed in the Appendix.

- Joint ANU-CSIRO Projects -'Ignition grants'.
- Annual conferences.
- Workshops.
- Seminars.
- Policy, outreach and communication.

3. CBA 2014-15 activities

3.1 Ignition projects

cba.anu.edu.au/opportunities/grants-funding/ignition-projects

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.

Fig 3.1 Images from a selection of current Ignition Projects (clockwise from top left): **1.** Genetic characterisation of formalin preserved fish tissue; **2.** Eucalyptus genomics; **3.** Effects of climate change on avian morphology; **4.** Can adaptation in 'ecosystem engineers' drive fire regime feedbacks?; **5.** Bill adaptation in parrots: finding loci involved in surface area increases by integrating morphometrics with NG; and **6.** Genetic and demographic impacts of contemporary disturbance regimes in Mountain Ash forests.

The scope of an Ignition project needs to be within the CBA's core focus of incorporating genomics, informatics or spatial modeling 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.

For the 2012-2013 funding rounds up to $5000 per project was offered. From June 2014, we made available up to $10,000 per project and continued this for the 2015 funding rounds.

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.

For the September 2015 round, the CBA also sought proposals for co-supervised ANU-CSIRO Honours projects. Our main goal with this funding was to facilitate ANU honours students spending time in CSIRO labs, providing valuable exposure to CSIRO scientists and research. Up to a $5000 student stipend could be requested as part of these proposals. Table 3.1 summarises the 11 Ignition projects CBA funded from Oct 2014-Sept 2015.

Table 3.1 2014-15 funded Ignition projects

	Project cba.anu.edu.au/research/projects	$
Mar 2015	**Genetic characterisation of formalin preserved fish tissue** Sharon Appleyard (CSIRO) and Maxine Piggott (ANU)	10,000 Lab work
Mar 2015	**Developing new methods for using distribution data to identify taxa that can tolerate extreme conditions** Xia Hua, Lindell Bromham, Marcel Cardillo (ANU) and ALA (CSIRO)	9,593 Salary
Mar 2015	**Effects of climate change on avian morphology** Janet Gardner, Loeske Kruuk (ANU) and Leo Joseph (CSIRO).	9923 Field & lab work
Mar 2015	**Genetic and demographic impacts of contemporary disturbance regimes in Mountain Ash forests** Brenton von Takach Dukai (ANU PhD student), Sam Banks (ANU) and Shannon Dillon (CSIRO).	10,000 Field & lab work
Sept 2015	**An exome capture system for phylogenetic and evolutionary studies in the hyperdiverse orchid tribe Diurideae (Orchidoideae)** Katharina Schulte, Mark Clements, Lars Nauheimer (CSIRO), Rod Peakall, Celeste Linde, Ryan Phillips (ANU)	10,000 Lab work & bioinformatics
Sept 2015	**Investigating the effects of diversity, distribution and chytrid load on Uperoleia frog skin microbial communities** Matt Morgan (CSIRO), Maxine Piggott, Renee Catullo (ANU)	9,987 Lab work
Sept 2015	**Bill adaptation in parrots: finding loci involved in surface area increases by integrating morphometrics with NGS *(Hons Project)*** Kerensa McElroy (CSIRO), Loeske Kruuk, Janet Gardner (ANU)	9,308 Lab work; $5K stipend
Sept 2015	**Can adaptation in 'ecosystem engineers' drive fire regime feedbacks?** Annabel Smith, Justin Borevitz (ANU), Shannon Dillon (CSIRO)	9,821 Salary
Sept 2015	**Curating spatial data to understand patterns and processes shaping biodiversity in New Guinea** Paul Oliver, Dan Rosauer, Eric Rittmeyer (ANU), Kristin Williams, Leo Joseph (CSIRO).	10,000 Salary
Sept 2015	**Environmental Drivers of Acacia-Associated Symbiotic Microbe Diversity** Russell Dinnage, Marcel Cardillo, (ANU), Anna Simonsen, Suzanne Prober, Luke Barrett, Pete Thrall (CSIRO)	9,750 Lab work
Sept 2015	**Linking genomic data to spatial biodiversity data in the Atlas of Living Australia** Caroline Chong, Justin Borevitz, Lindell Bromham (ANU), Rebecca Pirzl, John La Salle (CSIRO)	9,300 Salary

3.1.1 Progress reports (from Ignition grant recipients)

A test of the power of genotype by sequencing (GBS) for delimiting species boundaries among incipient species of Australian orchids. Rod Peakall, Celeste Linde (ANU) and Mark Clements (CSIRO)
cba.anu.edu.au/research/projects/species-boundaries-australian-orchids

- Progress on this ignition grant was delayed in 2013-14 due to staffing changes in the Peakall lab.
- We completed a pilot Genotype-by-Sequencing run across 96 samples of orchids spanning multiple genera.
- At least in this pilot phase we encountered a high degree of missing, data which somewhat limited the informativeness of the study. For example, within genera the number of SNPs with 70% of the samples had the SNP present was as follows: *Chiloglottis*=456 SNPs, *Drakaea*= 239 SNPS, *Caladenia* = 85 SNP.
- We also found surprisingly little sharing of polymorphic sites across species and closely related genera, with only 4 SNPs shared across all genera.
- These results have lead us to look at alternative NGS based methods for our needs, hence the application for the new ignition grant lead by Katharina Schultz (Table 3.1) 'An exome capture system for phylogenetic and evolutionary studies in the hyperdiverse orchid tribe Diurideae (Orchidoideae)'.

Bringing next generation approaches to conservation genomics using museum collections - Rock wallaby museum skinomics. Sally Potter, Maxine Piggott, Jason Bragg (ANU), Matt Morgan, Leo Joseph (CSIRO).
cba.anu.edu.au/research/projects/bringing-next-generation-approaches-conservation-genomics-using-museum-collections

- Museum skin samples were collected from a range of museums in Australia and samples have been extracted.
- We have run an exon capture on tissues and museum skins. These results are now being analysed.
- This project has been expanded to include scats and hair samples from captive rock-wallabies at Tidbinbilla, ACT.

Collections-based landscape genomics: red-browed finches as a test case.
Kerensa McElroy (CSIRO), Norman Warthmann (ANU).
cba.anu.edu.au/research/projects/collections-based-landscape-genomics-red-browed-finches-test-case

- We have completed shallow-pass WGS and analysis of 50 *Neochmia temporalis* samples. The approach worked; we genotyped a set of high quality nuclear markers as well as reconstructing full-length mitochondrial sequences for all samples.
- A structure analysis of the nuclear markers separated *N. temporalis* into three subspecies: *N. t. minor*, *N. t. temporalis*, and *N. t. loftyi*. These results suggest the Torresian and Murravian barriers may be important boundaries for this species, while the Burdekin Gap does not represent a barrier to gene flow.
- Notably, while the *N. t. minor* species is well known, *N. t. loftyi* is previously described based on only one individual, and has since not been found to be morphometrically or phenotypically distinct.
- A detailed analysis of nucleotide diversity and population genetic parameters (e.g. Tajima's D) of all mitochondrial genes showed rapid diversification of neutral alleles and no evidence of selection.
- Interestingly, the mitochondrial sequences do not distinguish *N. t. loftyi*, suggesting the Murravian barrier is at least semi permeable. A manuscript describing these findings is currently in preparation.

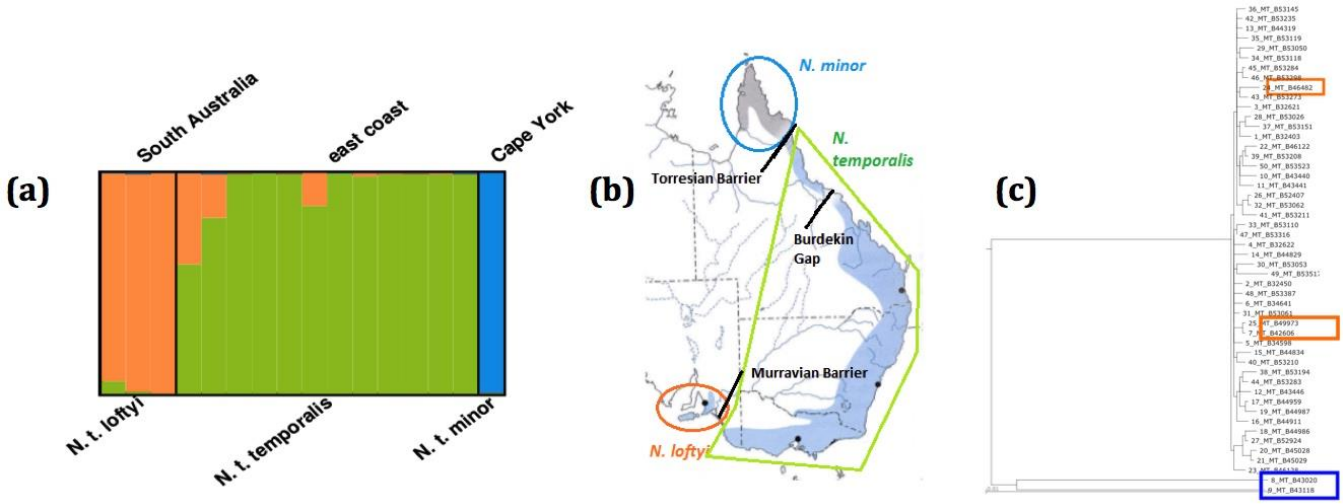


Figure 3.2 (a) Structure analysis of nuclear *N. temporalis* markers, showing subspecies subdivisions; **(b)** Map of *N. temporalis* range with structure results and potential biogeographical barriers superimposed; **(c)** Mitochondrial -joining tree showing lack of a distinct *N. t. loftyi* cluster (orange: *N. t. loftyi*; blue: *N. t. minor*).

Genetic characterisation of formalin preserved fish tissue: trial application of mini-barcodes and RAD-tags for species delineation.
Sharon Appleyard, John Pogonoski, Daniel Gledhill (CSIRO), Maxine Piggott (ANU).
cba.anu.edu.au/research/projects/genetic-characterisation-formalin-preserved-fish-tissue

- Maxine Piggott visited the ANFC (Hobart) in September 2015 to sample formalin preserved fishes of different ages. Sharon Appleyard and Maxine are now trialing different extraction methods and will assess whether the DNA obtained from formalin preserved fish will be suitable for NGS methods.
- Initial extractions by Sharon have reasonable DNA from 19-38ng/ul; although the A260/A280 ratios are not as good as fresh biopsy samples.
- All extracted DNA samples amplified with universal 16S primers and gave the appropriate amplicon size and will be sequenced to confirm species and determine if there is damage to the sequence.

Effects of climate change on avian morphology. Janet Gardner, Loeske Kruuk (ANU) and Leo Joseph (CSIRO)
cba.anu.edu.au/research/projects/effects-climate-change-avian-morphology

- Measurement of specimens was completed in August: we measured culmen length, depth, and width (for calculating bill surface area) for 3,800 individuals of 36 species housed in the Museum Collections in Sydney, Melbourne and Canberra.
- We have extracted the additional climate data (water vapour pressure) for 1970-2012 for the polygons that encompass each species' distribution.
- Data entry, compilation and checking is complete and we have begun exploratory analysis in R. Formal analyses will commence in late September with preparation of a manuscript to follow.

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

- The research phase for this project was commenced August 2015.
  We (ANU collaborators) have engaged in two meetings with our CSIRO Atlas of Living Australia collaborators (Drs John La Salle, Rebecca Pirzl, Lee Belbin and ALA team members) and identified future joint directions to integrate ANU biodiversity research with ALA resources and personnel - for example, identifying access via the ALA to priority environmental information layers (soil and freshwater data) and contributing analytical code to summarise environmental information with respect to point locality samples.
- We have also engaged and are working with CSIRO Centre for Australian National Biodiversity Research researchers (Drs Joe Miller and Nunzio Knerr) to utilise recently–generated plant data sets as our case study to explore the evolution of plant tolerance distributions.

3.1.2 Ignition Project Symposium

In recognition of 3.5 years of 20+ Ignition projects, our past and current grant recipients will be invited to share their progress and/or results at an informal half-day Ignition Project Symposium in early 2016. This will be open to all CBA members and other interested people.

3.1.3 Honours awards

cba.anu.edu.au/opportunities/grants-funding/cba-honours-awards

The CBA liaison committee has had several discussions about increasing, and better coordinating, the recruitment of HDR students into CSIRO labs. As an initial step, we agreed to focus on ANU honours students.

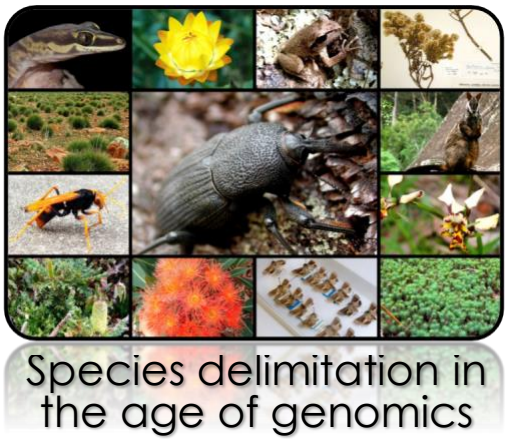
As mentioned above, we included Honours awards for up to $10,000 (including up to a $5000 stipend) in our September 2015 Ignition grant funding round. The proposed projects needed to allow for students to have considerable engagement with both their ANU and CSIRO labs. RSB or Fenner honours students could be co-supervised by a CBA-affiliated CSIRO scientist from BEKS or NRCA.

We funded one honours project in this initial round with the student, who will be co-supervised by staff at the ANWC, to start at the beginning of 2016 (Table 3.1).

We also promoted the NRCA and BEKS 2015 vacation scholarships on our website and via our email list.

3.2 CBA annual conference:
Species delimitation in the age of genomics

cba.anu.edu.au/news-events/species-delimitation-age-genomics



From 28-30 April 2015, CBA hosted its third annual conference at the Australian National Botanic Gardens (ANBG).

Our 2015 conference explored the impact of genomics on species discovery and delimitation in the context of taxonomic practice and applications.

Over three days, local and international speakers (Table 3.3) exposed Australian systematists to developing concepts, analytical techniques and software for genomic species delimitation (separate or simultaneous with phylogenetic inference), in the context of integrative taxonomy. The policy and public communication implications of species delimitation were also presented and discussed (see Policy, outreach and communication below).

Table 3.3 2015 conference - invited speakers

Speaker	Affiliation
Luciano Beheregaray	Biological Sciences, Flinders University
Remco Bouckaert	Computer Science, University of Auckland
Laura Boykin	Plant Energy Biology, ARC Centre of Excellence, University of Western Australia
Mark Burgman	CoE for Biosecurity Risk Analysis, School of Botany, University of Melbourne
Margaret Byrne	Science and Conservation, WA Department of Parks and Wildlife
Bryan Carstens	Evolution, Ecology, & Organismal Biology, Ohio State University
Lyn Cook	Biological Sciences, University of Queensland
Matt Fujita	Biology, University of Texas at Arlington
Dick Frankham	Biological Sciences, Macquarie University
Gilles Guillot	Informatics and Applied Mathematics, Technical University of Denmark
Paschalia Kapli	Scientific Computing Group, Heidelberg Institute for Theoretical Studies
John LaSalle	Atlas of Living Australia, NRCA, CSIRO
Alexander Mikheyev	Okinawa Institute of Science and Technology
Huw Ogilvie	Research School of Biology, Australian National University
Sally Potter	Research School of Biology, Australian National University
Dave Rowell	Research School of Biology, Australian National University
Kevin Thiele	Western Australian Herbarium, Department of Parks and Wildlife
John Wilkins	Historical and Philosophical Studies, University of Melbourne
Ziheng Yang	Genetics, Evolution and Environment, University College London

The meeting was jointly organised by the CBA (Craig Moritz) and NRCA, CSIRO (David Yeates and Leo Joseph), and supported by CBA, NRCA, ALA, Bioplatforms Australia and the ANBG.

The conference program was comprised of talks, technical presentations on current software and panel discussions by 19 invited speakers (Table 3.2), and 12 contributed lightning talks and 6 poster presentations by conference delegates. A public lunchtime talk, as part of the ANBG Friends seminar series, was also presented.

Over 80 delegates attended the meeting - 22 ANU; 16 CSIRO; 41 other (universities, museums, herbariums, state environment departments); and 17 HDR students.

Two travel grants of $750 AUD each were awarded to Early Career Researchers (PhD students from the University of Adelaide and Flinders University).

Table 3.3 2015 Conference budget

Expenses	$	Income	$
Speaker costs (flights, accom. etc.)	37880	CBA	40000
Catering	24360	NRCA/ALA	10000
Program, name tags	300	Bioplatforms Australia	2000
ECR travel grants	1500	Registration - Full ($225)	11925
Post conference field trip	150	Registration - Student ($85)	1105
TOTAL	**64190**	**TOTAL**	**65030**

Planning is underway for our 2016 Conference, with themes being developed and speakers sought around the topic of 'evolutionary data informing conservation and management policy'. Next year's conference will be moved from April to June to avoid teaching clashes (both here and internationally) and the Easter break.

3.3 Visiting scientists, training workshops and seminars

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

A major objective of CBA is to enhance collaboration and training opportunities via external visitors who will conduct a workshop and/or seminar during their visit to ANU and CSIRO. We welcome applications from CBA members on potential visitors and speakers throughout the year.

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, usually with a nominal registration fee (which goes towards catering, and helps ensure attendance after registration).

3.3.1 Workshops

In our third year we supported four visiting scientists (in addition to conference invited speakers) who presented a range of fully subscribed, well-received training workshops (Table 3.3).

Table 3.3 2014-15 Workshops presented by CBA-funded visiting scientists

Date	Workshop http://cba.anu.edu.au/research/highlights/cba-training-workshops	Participants	$
Oct 2014	**Genome assembly and target enrichment in non-model organisms** Matt Fujita (Texas). Invitation only, one day workshop.	24 Total 17 ANU 3 CSIRO 4 HDR students	3,500 *airfares, accom, catering*
Oct 2014	**DNA target enrichment in phylogenomics - molecular and bioinformatic principles** Oliver Niehuis. One day workshop.	20 Total 7 ANU 6 CSIRO 4 HDR students	5000 *Sponsorship of Aust. Ento. Soc. Conference*
Jun 2015	**Genomic and phenomics tools to identify the genetic basis underlying natural variation and adaptation** Olivier Loudet (INRA Versailles) & Justin Borevitz (ANU). Half day workshop.	21 Total 16 ANU 3 CSIRO 10 HDR students	5000 *airfares, accom*
Sept 2015	**Demographic inference for comparative phylogeograpy using Next-Gen sequence data** Alexander Xue (City Univ. New York)**.** Two day workshop.	28 Total 19 ANU 9 CSIRO 9 HDR students	*4,800* *airfares, accom*

Most CBA workshop topics to date have focused on advanced analytical/technical methods in population- and phylo-genomics, often with the primary developers of the methods presenting. In the future, we would like to organise more workshops relating to spatial ecology/macroecology and biodiversity informatics.

Also looking forward, CBA is in the planning stages of making a series of our workshops more regular (3-4 annually) and formal, such that participants will be able to obtain some sort of credit/recognition on completion, potentially as part of a course-work Masters program. These will complement RSB's new regular HDR skills training workshops (e.g. R, Python, etc), with CBA taking on the responsibility for advanced biodiversity/evolution short-courses.

In late 2015 a survey will be sent out to CBA members asking to rank their preferences for five main workshop topics to help gauge those that would be of most interest:

- Phylogenomics above and below the species level.
- Adaptation genomics.
- Museum genomics – technical methods & bioinformatics.
- Modeling biodiversity.
- Genome assembly.

However, we still plan to retain the ability to offer ad-hoc workshops to take advantage of visiting scientists with niche skills, and to respond to requests from CBA labs. One such workshop, to be held in the first half of 2016, will be on linking adaptation and speciation to macroevolution and macroecology.

3.3.2 Seminars

We also promoted and hosted several ad-hoc CBA seminars presented by scientists visiting ANU and CSIRO:

1. Mar 2015: Jérôme Chave (Evolution et Diversité Biologique, Université Paul Sabatier) **In-situ diversification versus migration patterns in the assembly of Neotropical plant lineages.**
2. Mar 2015 Emilie-Jane Ens (Macquarie Univ.) **ALA Two-way Indigenous Engagement Case Study.**
3. Sept 2015: John Woinarski (Charles Darwin University) and Barry Traill (Pew Charitable Trusts) **Making a Modern Outback - the future of nature and people in remote Australia**

3.4 Policy, outreach and communication

3.4.1 Atlas of Australia Two-way Indigenous Engagement Case Study

cba.anu.edu.au/research/projects/atlas-australia-two-way-indigenous-engagement-case-study

Based in SE Arnhem Land, this project aims to demonstrate the value of the ALA to Indigenous Australians, the value of Indigenous knowledge to non-Indigenous Australians and promote cross-cultural ways of knowing and managing Country.

The Aboriginal Yugul Mangi Rangers are working together with Emilie-Jane Ens and Mitchell Scott (Macquarie University), Craig Moritz (ANU) and John LaSalle (ALA, CSIRO).

Using local Indigenous knowledge, biodiversity data from SE Arnhem Land is being entered into the ALA using both Western scientific names and information, and indigenous names, uses and significance.

Lead researcher Emilie-Jane Ens was joined by Mitch Scott (RA), Kelvin Ironstone (Yugul Mangi Ranger) and Lester Gumbala and Nehemiah Farrell (students, Ngukurr School) to present a special CBA seminar (31 March 2015). After their seminar, Kelvin and the students had the opportunity to visit both the museum and wet labs (in the Gould Building at ANU) to see where some of the animals they had collected were sent and the types of research they were being used for.

3.4.2 The Conversation - Remote Indigenous communities are vital for our fragile ecosystems

theconversation.com/remote-indigenous-communities-are-vital-for-our-fragile-ecosystems-38700

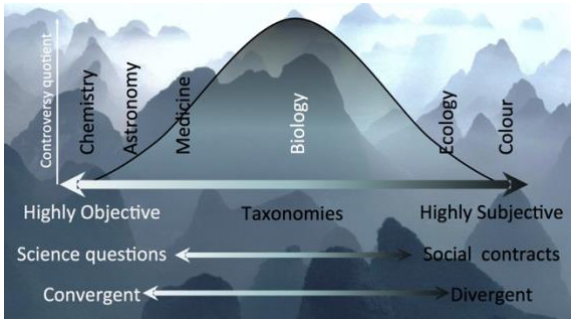
Amid the questioning of government support for remote Aboriginal communities and what Prime Minister Tony Abbott called the “lifestyle choices” of those who live there, CBA Director Craig Mortiz and CBA members Emilie-Jane Ens and Jon Altman highlighted the value of Aboriginal management to large areas of remote Australia in the article ‘Remote Indigenous communities are vital for our fragile ecosystems’ published in The Conversation (13 March, 2015).

An edited version of article was also used by The Alinytjara Wilurara Natural Resources Management Board (SA Caring for Country program) to support and encourage the work being undertaken in remote communities by Aboriginal people.

This article also led to positive engagement with the Pew Charitable Trusts, who are actively involved in Indigenous land management advocacy and policy in remote Australia (see Section 3.4.4).

3.4.3 Conference session

cba.anu.edu.au/news-events/species-delimitation-age-genomics



In the opening session of our 2015 Conference 'Species delimitation in the age of genomics' (see Section 3.2), our invited speakers highlighted some of the public communication, management and policy implications associated with genomic species delimitation:

- John Wilkins, 'Are species real, and if they are, do they need a theoretical definition and diagnostic?'
- Dick Frankham, 'Implications of different species concepts in conservation: the risks and consequences of over-splitting.'
- Margaret Byrne, 'Species delimitation in policy frameworks.'
- Kevin Thiele, 'The species problem – convergent, divergent or wicked?'
- Laura Boykin, 'Implications of species delimitation on global biosecurity.'

Kevin Thiele also presented a lunchtime public talk 'Species, taxonomy, genomics and you (a guide for the perplexed)' as part of the Friends of the Australian National Botanic Gardens seminar series. He spoke to a full-house and questions continued well after the event, highlighting the public interest in species discovery and delimitation, and the potential of new genomic technologies.

These policy and public communication talks were a complementary, and appreciated, addition to the more technical presentations on current species delimitation techniques and software. They initiated valuable discussions amongst the delegates both during the conference, and for future CBA science policy and outreach collaborations.

3.4.4 The Modern Outback - Pew Charitable Trusts

pewtrusts.org/en/projects/outback-australia

The Modern Outback is a campaign being run by Pew Charitable Trusts that aims to (re-)engage the Australian public with the 'Outback' such that its issues (and their solutions) can be discussed and supported. Pew are incorporating the support of Indigenous owners, natural resource management and conservation agencies, government, media, universities and the general public.

John Woinarski (Charles Darwin University) and Barry Traill (Pew Charitable Trusts) introduced Pew's Modern Outback campaign in a special CBA seminar 'Making a Modern Outback - the future of nature and people in remote Australia' (15 Sept 2015).

Pew's 'Modern Outback' campaign closely aligns with several CBA's activities, such as CBA Director Craig Moritz's research on reptile diversity and evolution in northern Australia on IPA lands, and the CBA co-funded Atlas of Australia Two-way Indigenous Engagement Case Study. Barry Traill also had suggestions on how to create media coverage for some of this work, including the potential of inviting journalists to join researchers on fieldtrips.

There have also been discussions with Barry Traill of the potential of applying for the 2017 Fenner Conference, an Australian Academy of Science sponsored program that aims to bring together those with relevant scientific, administrative and policy expertise to consider current environmental and conservation problems in Australia (applications are due June 2016).

3.4.5 QuestaGame

portal.questagame.com

QuestaGame is a digital app developed by a local, Canberra-based software company that uses social gaming technologies to engage people in the natural environment by submitting wildlife sightings and earning points to compete with other players.

As the first company to begin "scoring" species data dynamically, QuestaGame is becoming a leader in biodiversity economic modelling.

The citizen-science data collected are added to ALA/GBIF. Other partners include the Office of Environment and Heritage NSW, the ACT Government, the Global Information Biodiversity Facility, and others.

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, CBA will initially collaborate with QuestaGame by:

1. Putting the call out to CBA members who may be interested in being involved as specialists for QuestaGame's "Bio-Expertise Engine (BEE)" to identify sightings.
2. Promoting to our HDR students a 3-month internship (with stipend) that QuestaGame have developed to give students the opportunity to work with them.
3. Hosting a special CBA seminar (2016) by QuestaGame developer Andrew Robinson.

3.4.6 Potential future policy, outreach and communication activities

1. Briefings and two-way conversations to government environment departments (both federal, state and local where appropriate) by CBA members. These will aim to (i) disseminate new biodiversity knowledge based on CBA research, and (ii) determine what information policy makers and mangers need from biodiversity scientists.
2. Public seminars by CBA Director Craig Moritz (and others, especially ECRs) to present new biodiversity science methods and discoveries to the broader public, including ANU alumni.

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

Nothing to report other than that above.

5. Interactions and developing interactions with third parties.

5.1 Science and Industry Endowment Fund (SIEF)

CSIRO has been working with ANU to establish a National Agricultural and Environmental Sciences Precinct via the SIEF Research Infrastructure (SIEF RI) program.

Craig Moritz, on behalf of the CBA was involved in a bid to the SIEF Board for infrastructure investment in genomics, metabolomics and informatics. The $18 million bid was successful, and the National Agricultural and Environmental Sciences Precinct (NAESP) was launched in December 2014.

The SIEF grant is being used to develop:

- The Centre for Genomics, Metabolomics and Bioinformatics (CGMB);
- A collaborative ecogenomics lab and computer facility that will accessible to ANU and CSIRO researchers; and
- A new life sciences building at CSIRO Black Mountain.

Craig Moritz will be directly involved initially in the management of the joint ecogenomics lab, and CBA will host the launch of the new lab in early 2016, running the inaugural workshop (technical methods and bioinformatics) to be held at the facility. CBA will continue to play a role in the delivery of the lab's training workshops and CBA's webpage will be used to disseminate public and user information for the lab.

The establishment of this innovation and training lab, at the interface of genomics, bioinformatics and spatial modelling, will continue to facilitate collaborations in biodiversity science across ANU and CSIRO.

5.2 The Outback - Pew Charitable Trusts

See above (Policy, outreach and communication Section 3.3.4)

5.3 QuestaGame

See above (Policy, outreach and communication Section 3.3.5)

6. Financial statement

- The core CBA budget is $200K/year, shared equally by CSIRO and ANU.
- In the Centre's third year, funds were allocated to the Experimental genomics facility, Ignition projects, our second annual conference, external visitors and ECR-led training workshops.
- In our fourth year, Ignition projects, workshops, our annual conference, visiting scientists and co-supervised honours projects will continue to be funded.
- Fourth-year spending will also focus on communication and public policy engagement, with CBA coordinator Claire Stephens increasing her hours from 18 hours to 24 hours a week from 1 March 2016. Her extra time will be used to work on CBA communication and policy areas.
- Carryforward into 2015/16 is approx. $60K and we have budgeted to spend this down over the 2015-16 year.
- A statement of Income and Expenditure (for 1 July 2014 - 30 June 2015) prepared by ANU Finance is attached to this report.

Table 6.1 Budget summary

Item	Yr 2 proposed	Yr 2 actual	Yr 3	Yr 4 (15-16)	Notes for Yr4
Coordinator: C Stephens (50%)	40	40	41	60	Propose increase from 50%->70% (CS costs: approx. $45K pa -> $60K)
Outreach & promotion	30	0	80	15	
Projects (now includes fieldwork, travel and honours)	70	70	60	80	Ignition projects
Hardware & equipment	15	11	25	10	Possible contribution to MEC, LIEF etc.
Bioinformatics support: J Bragg (24%)	27	28	28	30	Six months to 7/15
Annual symposium & training workshops	50	37	50	50	June conference + $20K new workshops
Visiting scientists	30	0	20	15	
Carryforward	-65		-170	-60	~ $60K carryforward from 14-15
Total	**197**	**186**	**134**	**200**	

Appendix

CBA activities: August 2012-October 2015

Joint ANU-CSIRO Projects - 'Ignition grants'

1. **An exome capture system for phylogenetic and evolutionary studies in the hyperdiverse orchid tribe Diurideae (Orchidoideae)** Katharina Schulte, Mark Clements, Lars Nauheimer (CSIRO), Rod Peakall, Celeste Linde, Ryan Phillips (ANU) (Sept 2015).
2. **Investigating the effects of diversity, distribution and chytrid load on Uperoleia frog skin microbial communities** Matt Morgan (CSIRO), Maxine Piggott, Renee Catullo (ANU) (Sept 2015).
3. **Bill adaptation in parrots: finding loci involved in surface area increases by integrating morphometrics with NGS** (Hons Project) Kerensa McElroy (CSIRO), Loeske Kruuk, Janet Gardner (ANU) (Sept 2015).
4. **Can adaptation in 'ecosystem engineers' drive fire regime feedbacks?** Annabel Smith, Justin Borevitz (ANU), Shannon Dillon (CSIRO) (Sept 2015).
5. **Curating spatial data to understand patterns and processes shaping biodiversity in New Guinea** Paul Oliver, Dan Rosauer, Eric Rittmeyer (EEG, RSB), Kristin Williams (CSIRO Land & Water), Leo Joseph (ANWC, CSIRO).
6. **Environmental Drivers of Acacia-Associated Symbiotic Microbe Diversity** Russell Dinnage, Marcel Cardillo, (ANU), Anna Simonsen, Suzanne Prober, Luke Barrett, Pete Thrall (CSIRO) (Sept 2015).
7. **Linking genomic data to spatial biodiversity data in the Atlas of Living Australia** Caroline Chong, Justin Borevitz, Lindell Bromham (ANU), Rebecca Pirzl, John La Salle (CSIRO) (Sept 2015).
8. **Genetic characterisation of formalin preserved fish tissue** Sharon Appleyard (CSIRO) and Maxine Piggott (ANU) (Mar 2015).
9. **Developing new methods for using distribution data to identify taxa that can tolerate extreme conditions** Xia Hua, Lindell Bromham, Marcel Cardillo (ANU) and ALA (CSIRO) (Mar 2015).
10. **Effects of climate change on avian morphology** Janet Gardner, Loeske Kruuk (ANU) and Leo Joseph (CSIRO) (Mar 2015).
11. **Genetic and demographic impacts of contemporary disturbance regimes in Mountain Ash forests** Brenton von Takach Dukai (ANU PhD student), Sam Banks (ANU) and Shannon Dillon (CSIRO) (Mar 2015).
12. **Eucalyptus genomics project** Linda Broadhurst, David Bush, Brendan Lepschi, Justin Borevitz (ANU), Norman Warthmann (ANU), Megan Supple (ANU) and Jason Bragg (ANU) (Jun 2014).
13. **Bringing next generation approaches to conservation genomics using museum collections – Rock wallaby museum skinomics** Sally Potter (ANU), Maxine Piggott (ANU), Jason Bragg (ANU), Matthew Morgan (CSIRO), Leo Joseph (CSIRO) (Jun 2014).
14. **Collections-based landscape genomics: Red-browed finches as a test case** Kerensa McElroy (CSIRO), Norman Warthmann (ANU) (Jun 2014).
15. **Penguin ectoparasites of the Southern Hemisphere** Katherine Moon (ANU PhD student), Ceridwen Fraser (ANU), Bruce Halliday (CSIRO) (Jun 2014).
16. **Genome skimming with degraded DNA from herbarium specimens** Alexander Schmidt-Lebuhn (CSIRO), Adrienne Nicotra (ANU) (Jun 2014).
17. **Molecular phylogeny of *Helicoverpa* from museum specimens** Andreas Zwick (CSIRO), David Yeates (CSIRO), Tom Walsh (CSIRO), Karl Gordon (CSIRO), Craig Moritz (ANU), Dave Rowell (ANU) (Jun 2014).
18. **Palaeoecological indicators of biodiversity change through time** Simon Haberle (ANU), Dan Rosauer (ANU), Geoff Hope (ANU), Kristen Williams (CSIRO) (Aug 2013).
19. **Future ecosystem states: linking ecophysiological cues and thresholds to climatic regimes, variability and weather extremes** Kristen Williams, Simon Ferrier (CSIRO), Craig Moritz (ANU) (Jun 2013).
20. **A curation community for coral environmental genomics** Alexie Papanicolaou, Owain Edwards (CSIRO), Sylvain Forêt (ANU) (Jun 2013).
21. **A test of the power of genotype by sequencing (GBS) for delimiting species boundaries among incipient species of Australian orchids** Rod Peakall, Celeste Linde (ANU), Mark Clements (CSIRO) (Jun 2013).
22. **Evolutionary processes in Billy buttons** Alexander Schmidt-Lebuhn (CSIRO), Justin Borevitz (ANU) (Jun 2013).
23. **Species discovery and refugia in the monsoonal tropics** Craig Moritz, Scott Keogh (ANU), Justin Perry, Eric Vanderduys, Simon Ferrier (CSIRO) (Oct 2012).
24. **Hybrid history: deep sequencing of the Tasmanian blue gum** Carsten Kulheim (ANU), Joe Miller (CSIRO) (Oct 2012).
25. **How local is local? Landscape genomics in Yellow box** Justin Borevitz (ANU), Linda Broadhurst (CSIRO) (Oct 2012).

Annual conferences

1. **Species delimitation in the age of genomics** (Apr 2015).
2. **Understanding biodiversity dynamics using diverse data sources** (Apr 2014).
3. **Biodiversity genomics** (Apr 2013).

Workshops

1. Alexander Xue (City Univ. New York) **Demographic inference for comparative phylogeograpy using Next-Gen sequence data** (Sept 2015)
2. Olivier Loudet (INRA Versailles) & Justin Borevitz (ANU) **Genomic and phenomics tools to identify the genetic basis underlying natural variation and adaptation** (June 2015).
3. Oliver Niehuis (Zoologisches Forschungsmuseum Alexander Koenig) **DNA target enrichment in phylogenomics - molecular and bioinformatic principles** (Oct 2014).
4. Dan Rabosky (Univ. Michigan) **Computational macroevolution and phylogenetic comparative methods** (Sept 2014).
5. 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).
6. Australian Bioinformatics Network **R Bootcamp** (Oct 2013).
7. Alexei Drummond (Univ. Auckland) **Phylogenomics using BEAST2** (July 2013).
8. Rod Peakall (ANU) & Peter Smouse (Rutgers Univ.) **GenAlEx: Genetic analysis for population studies** (July 2013).
9. Steve Stones-Havas (Biomatters) **Geneious** (Apr 2013).
10. Joseph Heled (Univ. Auckland) **BEAST2** (Apr 2013).

Seminars

1. 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).
2. Emilie-Jane Ens (Macquarie Univ.) **ALA Two-way Indigenous Engagement Case Study** (Mar 2015).
3. 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).
4. Matthew Barrett (Botanic Gardens and Parks Authority & UWA) **Diversity and diversification of the Kimberley flora** (Jun 2014).
5. Eddie Holmes (Univ. Sydney) **The Greatest Experiment in Evolution: Viral Biocontrol of Rabbits** (Mar 2014).
6. Alan Andersen (CSIRO) **Historical biogeography shapes community ecology** (Feb 2014).
7. Alexei Drummond (Univ. Auckland) **Developing Darwin's computer** (Jul 2013).

Policy, outreach and communication

1. Conference session: **Public communication and policy issues associated with species delimitation** (2015).
2. Conversation article: **Remote Indigenous communities are vital for our fragile ecosystems** Craig Moritz, Emilie-Jane Ens and Jon Altman (2015).
3. Project: **Atlas of Living Australia Two-way Indigenous Engagement Case Study** (2014-15).
4. Evening science discussion: **Current practices and future goals for conservation planning based on the increasing availability of new, large-scale biodiversity data** (2014 conference).
5. Conference workshop: **The contribution of biodiversity genomics to policy and management** (2013).