Australian Transect Network (ATN)

Biodiversity Adaptation Transect Sydney (BATS)

The BATS aims to:

- Improve understanding of what controls the composition of ecosystems, and helps identify and monitor the drivers of change.
- Characterize the relative impacts of plasticity versus local adaptation within a replicated (multiple plots, multiple species), dynamic, and connected system.
- Uncover the mechanisms leading to evolutionary diversification.
- Establish predictive measures of resilience to change.

To do so environmentally driven shifts are investigated within a single highly diverse vegetation type (the nutrient-poor sandstones of the Sydney basin) along a short but steep environmental gradient (altitudinal and rainfall gradients between the coast and the Capertee Valley, west of the Great Dividing Range). An observational and experimental landscape-scale approach is used to investigate taxonomic, functional, genetic and genomic turnover along a natural environmental gradient. The research is conducted in three parts:

1) Plot-based research along an environmental transect traversing the sandstone soils of the Sydney region exploring species turnover across altitudinal and rainfall gradients.
2) Research contrasting plastic versus adaptive variation in two species co-occurring along the same environmental gradient.
3) Research which places genetic turnover along the transect into the broader context of genetic variation across the entire distributional range of the same species. This helps determining whether altitudinal variation is similar to latitudinal variation.

Table App.II.1. Biodiversity Adaptation Transect Sydney description.

Research infrastructure themes	1. Ecosystem turnover along rainfall and altitudinal gradients. 2. Taxonomic, functional and genetic turnover along the transect. 3. Links between phenotypic/genomic plasticity and selective response for key species across environmental gradients.
Data type	*Vegetation*: Abundance, Traits (plant height, leaf and seed dimensions, leaf and seed characteristics), functional diversity, and specimens (for identification and DNA analysis). *Fungi:* Diversity *Climate*: Temperature.
Location	Sydney coast to the Capertee Valley in New South Wales
Survey boundary coordinates	(151.28337 : -33.58846), (150.12088 : -33.32167), (151.2827 : -33.53835), (150.05344 : -33.13691), (151.08574 : -34.13574), (151.08574 : -34.13574), (150.31958 : -33.64788), (150.22719 : -33.07954), (150.59 : -33.20335),
Transect length	200 km

Plots	36/35 plots of 50x50m (9 form part of the AusPlots network).
Year established	2011
Revisit (ideal) frequency	1 / (3 to 5 years)
Temporal Extent (Publication Date)	08/09/2011 to 19/10/2016 (31/01/2018)
Rainfall Gradient (annual mean)	1,360 mm - 620 mm
TERN Facilities on Transect	AusPlots, ASN, LTERN, OzFlux
Leader	Maurizio Rossetto (Maurizio.rossetto@rbgsyd.nsw.gov.au)
Collaborators	Royal Botanic Gardens and Domain Trust Macquarie University The University of Sydney Australian Research Council
Publications	Ausplot data: http://www.aekos.org.au/collection/adelaide.edu.au/ausplotsrangelands
Links	http://aekos.org.au/index.html#/search-results/list/dataset-details-a?datasetId=au.org.aekos.transform.generated.subgraph.impl.entities.SURVEYSUBGRAPH:T1516672395133 https://www.rbgsyd.nsw.gov.au/Science-Conservation/Our-Work-Discoveries/Evolutionary-Ecology/Biodiversity-and-Adaptation-Transect-Sydney-(BATS)

North Australian Tropical Transect (NATT)

Savannas, featuring an open tree canopy and dense grass layer, are the dominant ecosystems of northern Australia. Pastoralism is the most extensive land-use, but the main income earners are mining and tourism. Aboriginal owners are major stakeholders, both in terms of population and land title. In contrast to those overseas, Australia's savannas are little-modified by human activity, and harbour their full complement of biological diversity. In the face of increasing pressure to develop northern Australia, the challenge is to ensure that these ecosystems remain healthy and biological diversity is conserved for future generations.

The NATT follows the rainfall gradient that runs from the northern coast near Darwin (1700 mm mean annual rainfall) south to the fringe of the arid zone (500 mm). It covers a range of savanna ecosystem types, from monsoonal tall-grass systems with high tree cover near the coast, to dry spinifex hummock grasslands with low tree cover in the south. The NATT provides a framework for:

- Monitoring and modelling the dynamics of Australia's tropical savannas in relation to variation in soils and disturbance (primarily fire and grazing).
- Identifying and monitoring ecosystem transitions in the context of climate change.

Ant surveys sampled species richness and composition using pitfall traps on three occasions in 1996 and 1997 at 1-ha sand, loam and clay sites at each of five locations along the 600 km NATT to determine species diversity.

Table App.II.2. South-Western Australian Transitional Transect description.

Research infrastructure themes	1. Ecosystem turnover along rainfall and soil gradient. 2. Predictive understanding of tree and carbon dynamics in relation to environmental stress and disturbance. 3. Predict biodiversity responses to climate change and disturbance, using ants as a focal taxon.
Data type	*Soils*. *Vegetation*: Composition and structure data, vouchers, genetic material. *Ant*: richness and composition data, vouchers, genetic material.
Location	North coast near Darwin to the fringe of the arid zone in the south in the Northern Territory
Survey boundary coordinates	(130.75472 : -17.30806), (130.82657 : -17.35732), (130.82657 : -17.35732), (130.88573 : -16.09323), (131.72399 : -15.09093), (131.81806 : -12.83167), (131.36361 : -12.6825), (130.82677 : -17.35732),
Transect length	1,000 km
Plots	15 plots
Year established	1996
Revisit (ideal) frequency	*Soil surveys:* 1 / (5 years) *Vegetation surveys:* 1 / (5 years) *Ant surveys:* 1 / (3 to 5 years)
Temporal Extent (Publication Date)	*Ant surveys data:* 07/1996 to 10/1997 (01/05/2016)
Rainfall Gradient (annual mean)	1,700 mm on the northern coast - 500 mm on the fringe of the arid zone
TERN Facilities on Transect	AusCover, AusPlots, ASN, LTERN,OzFlux

Leader	Prof Alan Andersen (Alan.Andersen@cdu.edu.au)
Collaborators	Charles Darwin University, NT, Australia Max Planck Institute, Germany University of Massachusetts, USA
Publications	Ant data: http://www.aekos.org.au/collection/csiro/natt/ants9697 Ant data: http://www.aekos.org.au/collection/csiro/natt/ants1213 Ausplots data: http://www.aekos.org.au/collection/adelaide.edu.au/ausplotsrangelands
Links	*Ant surveys data:* http://aekos.org.au/index.html#/search-results/list/dataset-details-a?datasetId=au.org.aekos.transform.generated.subgraph.impl.entities.SURVEYSUBGRAPH:T1510616080372

South-Western Australian Transitional Transect (SWATT)

The SWATT is an ecological infrastructure initiative developed to measure biophysical processes and biodiversity attributes. This infrastructure informs key ecosystem science questions and assists with the development and validation of ecosystem models. Research underpinned by SWATT data enables better management and provides evidence to support sustainable development, landscape restoration, and increased ecosystem resilience.

The SWATT incorporates an internationally recognised biodiversity hotspot, the Southwest Botanical Province (Myers et al. 2000, Hopper P & Gioia 2004); a national biodiversity hotspot (Central and Eastern Avon Wheatbelt); and the evolutionary significant species rich Southwest Interzone (Hopper 1979, Gibson et al. 2010), which includes the globally significant Great Western Woodlands (Watson et al. 2009). It also intercepts another two national significant phytogeographic transitional zone, the Triodia-Acacia line (Beard 1975) and the Menzies line (Butt et al. 1977). The SWATT captures several biophysical gradients that can drive species selection, influence community composition, and determine assemblage distributional patterns across the landscape. The SWATT aims to inform multiple ecosystem science questions, including:

- How biodiversity is partitioned across the landscape at a gene, species and community level in response to biophysical processes.
- How species, population and regional scale genetic variability responds to biophysical gradients.
- To what extent this response confers an adaptive advantage to climate change.

Table App.II.3. South-Western Australian Transitional Transect description.

Research infrastructure themes	1. Temporal and spatial changes in community composition and soil carbon in response to changes in environmental gradients. 2. Benchmarking the habitat specificity, phenotypic plasticity and variability in stress response genes for key species across environmental gradients.
Data type	*Soil:* macronutrient status and soil texture; for all sites. *Vegetation:* structure and vascular flora; for all sites. *Vertebrates:* At most sites. *Invertebrates:* Spiders, beetles, and ants; at most sites.
Location	South west Western Australia, from Walpole on the south coast to beyond Matuwain in the Little Sandy Desert.
Survey boundary coordinates	(120.65553 : -27.4377), (120.69218 : -27.38191), (117.26719 : -34.59954), (117.15654 : -34.61918), (119.19381 : -32.86725), (117.75537 : -34.47693), (120.69968 : -27.38827), (120.69116 : -27.38189), (117.15533 : -34.61928), (117.15533 : -34.61928), (121.01471 : -28.06515), (117.15553 : -34.61928), (121.01472 : -28.06424), (120.66669 : -30.53042), (117.15533 : -34.61908), (117.15543 : -34.61828), (120.31896 : -31.19566),
Transect length	1,200 km
Plots	40 plots
Year established	2013
Revisit (ideal) frequency	1 / (3 to 5 years)
Temporal Extent (Publication Date)	27/.08/2013 to 04/11/2013 (30/11/2014)
Rainfall Gradient (annual mean)	800 mm on the coast to 250 mm inland

TERN Facilities on Transect	AusCover, AusPlots, ASN, OzFlux
Leader	Dr Stephen van Leeuwen (Stephen.vanleeuwen@DPaW.wa.gov.au)
Collaborators	WA Department of Parks and Wildlife CSIRO University of Adelaide
Publications	Soil and vegetation: http://www.aekos.org.au/collection/wa.gov.au/swatt
Links	http://aekos.org.au/index.html#/search-results/list/dataset-details-a?datasetId=au.org.aekos.transform.generated.subgraph.impl.entities.SURVEYSUBGRAPH:T1510625491849

Transect for Environmental Monitoring and Decision-Making (TREND)

Climate change threatens plant biodiversity, exacerbating existing impacts such as habitat fragmentation. Species assemblages are changing in response, resulting in poleward and uphill shifts in terrestrial ecosystems that are important to understand for appropriate conservation planning. South Australia (SA) has experienced a warming trend of 0.5–1.5°C since 1950 and continuing warming and drying trends have been forecast. The Mount Lofty and Flinders Ranges region of SA is a biodiversity hotspot that conserves range-edge species and is climate sensitive. Systematic monitoring enables us to predict and track ecosystem change by observing and determining the drivers of species distributions.

The TREND is a long-term research infrastructure and monitoring program dedicated to understanding how species and ecosystems change over space and time. The TREND provides a system of data collection across SA's native ecosystems. Plots are located along a north-south 1000 km transect running along the Adelaide Geosyncline in the Mount Lofty Ranges and Flinders Ranges, from Deep Creek on the coast to north of Arkaroola. Data consist of vascular plant species and ant composition and diversity, vegetation cover and structure, as well as aspect and soil properties. As well as a baseline for monitoring, these data has been used to analyse variation in species composition with geographic and environmental changes. By assessing the impacts of various potential climatic and environmental shifts, the TREND provides an early warning system for changes in the environment as well as a legacy of long-term monitoring, informed policy and proactive response to climate change.

Table App.II.4. Transect for Environmental Monitoring and Decision-Making description.

Research infrastructure themes	1. Ecosystem turnover along rainfall and temperature gradient. 2. Benchmarking the habitat specificity, phenotypic plasticity and variability in stress response genes for key species across environmental gradients within the major biomes of the south Mediterranean/arid transition.
Data type	*Soils:* chemistry (ions concentrations, pH), nutrients, texture, slope, a*spect, and topography.* *Vegetation:* species composition and diversity, cover, and structure. *Ant:* species composition and diversity.
Location	Mount Lofty and Flinders Ranges in South Australia from Deep Creek on the coast to north of Arkaroola.
Survey boundary coordinates	Polygon: (139.6137695 -35.7440083,139.6137695 -29.8760803,137.8779297 -29.8760803,137.8779297 -35.7440083,139.6137695 -35.7440083)
Transect length	1,000 km
Plots	150 plots of 900m^2 in 85 study locations
Year established	2011
Revisit (ideal) frequency	1 / (3 to 5 years)
Temporal Extent (Publication Date)	*Vegetation and Soils:* 30/08/2011 to 01/12/11 (06/01/2015)
Rainfall Gradient (annual mean)	1,100 mm on the coast to 140 mm in the northern arid region
TERN Facilities on Transect	AusPlots
Leader	Dr Greg Guerin (greg.guerin@adelaide.edu.au)

Collaborators	University of Adelaide Flinders University University of South Australia South Australia Department of Environment and Natural Resources South Australian Research and Development Institute
Publications	*Soil and vegetation*: http://www.aekos.org.au/collection/adelaide.edu.au/trend *Ausplots*: http://www.aekos.org.au/collection/adelaide.edu.au/ausplotsrangelands *Vegetation plot data 2011:* doi:10.4227/05/54AB6B443D1D3 *Research article (vegetation and soils):* https://doi.org/10.1111/jvs.12111
Links	*Vegetation and Soils:* https://onlinelibrary.wiley.com/doi/abs/10.1111/jvs.12111 http://www.trendsa.org.au

Australian East Coast *Drosophila* Transect (EADrosT)

Clinal variation patterns arise when there are continuous changes in traits or genes over space. They provide a powerful approach to identifying traits and genes associated with environmental variation. The wide range of climatic conditions along the eastern Australian coast represents an outstanding natural laboratory for the study of traits and genes that are associated with climatic adaptation. The Drosophila Clinal Data Collection contains more than 15 years of data collected on populations of eight drosophilid species along the eastern coast of Australia.

The EADrosT is a coastal transect running north from Hobart (400 mm mean annual rainfall) in Tasmania to Cooktown (2800 mm) in Queensland. It aims to:

- Monitor the dynamics of evolutionary adaptation to climate change in Drosophila flies along a temperate-to-tropical gradient.
- Track species composition changes under climate change and understand driving forces.
- Determine the genes and genetic processes underlying adaptive evolution.
- Track the speed of response to contemporary environmental change.

Specific major research questions include:

- How quickly can adaptive changes to different conditions evolve?
- What is the role of average versus extreme conditions in dictating species ranges and range shifts?
- What is the nature of genetic processes underlying climate change adaptation?

Table App.II.5. Australian East Coast Drosophila Transect description.

Research infrastructure themes	1. Shifts in genetic markers in response to climate. 2. *Drosophila* species distribution shifts under climate change. 3. Identification of ectotherm traits linked to thermal adaptation.
Data type	*Drosophila*: species composition, endosymbionts, quantitative traits and genes where appropriate.
Location	Along the east coast of Australia, from Hobart in Tasmania to Cooktown in Queensland.
Survey boundary coordinates	
Transect length	4,000 km
Plots	20 plots
Year established	2003 (original sampling 1970s and 1980s)
Revisit (ideal) frequency	Sporadic.
Temporal Extent (Publication Date)	
Rainfall Gradient (annual mean)	400 mm - 2800 mm
TERN Facilities on Transect	AusPlots, ASN, LTERN, OzFlux
Leader	Professor Ary Hoffmann (ary@unimelb.edu.au)
Collaborators	University of Melbourne

	Monash University
Publications	Data: http://adeer.pearg.com/ Papers and reports: http://adeer.pearg.com/biogs/DR00015b.htm
Links	

Box Gum East-West Transect (BoxEW)

The BoxEW transect is centred around key high-quality remnants of grassy box woodlands, from Yellow Box to Red Gum woodlands on the New South Wales Southern and Central Tablelands, through White Box woodlands on the NSW Central West Slopes, to Grey and Poplar Box woodlands on the NSW Central West Plains. It captures a rainfall gradient of 400 mm in an east-west direction across box gum woodlands in central NSW, and incorporates major shifts at the family level in woodland plant composition. Along each part of the gradient, woodland remnants with minimal livestock grazing history form the core set of sites, and are variously contrasted with sites modified by livestock grazing to elucidate interactions with land use and climate. The BoxEW transect was established to facilitate restoration and climate adaptation of biodiversity and ecological processes in these wheatbelt ecological communities, and has contributed to decisions regarding listing of threatened Ecological Communities at National and State levels.

Table App.II.6. Box Gum East-West Transect description.

Research infrastructure themes	1. Effects of interactions between landuse and climate on floristic composition. 2. Landuse effects on soil biophysical and chemical properties. 3. Effects of climate gradient on within-species variation in plant traits and genomic adaptation
Data type	*Soil:* chemical and biophysical data; partial. *Floristic:* For whole site. *Key species:* ecophysiological trait and genomic data (underway).
Location	Central New South Wales.
Survey boundary coordinates	
Transect length	386 km
Plots	Floristic data: 19 relocatable plots. Other: 60 relocatable and non-relocatable plots
Year established	1996
Revisit (ideal) frequency	Opportunistic
Temporal Extent (Publication Date)	
Rainfall Gradient (annual mean)	800 mm - 400 mm
TERN Facilities on Transect	Nil
Leader	Dr Suzanne Prober (Suzanne.Prober@csiro.au)
Collaborators	CSIRO University of Tasmania Department of the Environment and Energy
Publications	
Links	https://www.csiro.au/en/Research/LWF/Areas/Ecosystems-biodiversity/Monitoring-biodiversity/Agricultural-landscape-biodiversity

Wet Tropics Altitudinal Transect (WTAT)

The Wet Tropics World Heritage Area in north-eastern Queensland is the largest area of tropical rainforest in Australia and supports the highest biodiversity – about 45 per cent of all vertebrate species - of any region in the country. In 2014, the Wet Tropics World Heritage Area was ranked the second most irreplaceable natural terrestrial World Heritage site on Earth because of its unique concentration of endemic, rare and ancient species. The vertebrate fauna of the Wet Tropics has outstanding and exceptionally high levels of endemism and diversity, with the highest concentration in the mountain rainforests. Long-term monitoring demonstrates that the biodiversity of the World Heritage Area is declining, with many species already reduced in both distribution area and population size, despite being well-managed within a protected area. These impacts have been caused by diseases, habitat fragmentation, and climate change. Climate change is already causing significant impacts with many species disappearing at the lower elevation, warmer part of their range.

The WTAT is located in the central Wet Tropics of Queensland. It extends 600 kilometres from the coast to an elevation of 1200 metres. For more than 20 years, biodiversity monitoring has been conducted along the WTAT with sites at 200 metre elevational intervals, from sea-level to the tops of the mountains in each of the major mountain ranges of the region. The WTAT dataset consists of > 400,000 vertebrate records; > 11,500 standardised surveys of birds, reptiles, frogs, and small mammals; and > 13,000 DNA tissue samples. Additionally, there is extensive information based on a variety of invertebrate groups, habitat descriptions, and millions of microclimate measurements. Long-term research based on the WTAT has provided detailed insights into the most important drivers of biodiversity in the region and led the way in identifying global climate change as a severe threatening process in the tropics, and the potential for species extinction in mountain systems around the world. The science from the WTAT has made a significant contribution to conservation planning and management at the state, national, and international levels.

Table App.II.7. Wet Tropics Altitudinal Transect description.

Research infrastructure themes	1. Understanding patterns and processes driving biodiversity in the tropical rainforests of the region. 2. Predicting the impacts of climate change on biodiversity. 3. Conservation management and climate change.
Data type	*Microclimate.* *Vegetation:* Structure. *Animals:* Standardised surveys of invertebrates, reptiles, frogs, birds, and mammals.
Location	Australian Wet Tropics, north-eastern Queensland between Townsville and Cooktown.
Survey boundary coordinates	
Transect length	600 km
Plots	> 100 plots (with replicate sampling points)
Year established	1995
Revisit (ideal) frequency	Primary sites: (3 to 4) / year Secondary sites: 1 / year
Temporal Extent (Publication Date)	

Rainfall Gradient (annual mean)	1,200 mm - 8,000 mm
TERN Facilities on Transect	AusCover, AusPlots, ASN, LTERN, OzFlux
Leader	Professor Stephen Williams (Stephen.williams@jcu.edu.au)
Collaborators	CSIRO James Cook University
Publications	Data: http://www.aekos.org.au
Links	http://www.wettropics.gov.au/site/user-assets/docs/sowt2015-16b5-lres.pdf http://esapubs.org/archive/ecol/E091/181/default.htm