Measuring adaptation to a rapidly changing environment

Understanding the relative degrees of resilience and ability of organisms, communities and ecosystems to adapt to a rapidly changing environment will be essential to predicting their ability to survive in near future conditions and to understanding changes in ecosystem function. Horizontal gene transfer, epigenomic modification, changes in the microbiome and other "horizon" areas of –omics research could confer the phenotypic plasticity to individuals, populations, and communities, that will be required to expand physiological tolerances. Our collective capability in genomics has us well placed to build capacity in this emerging research area.

Problem Statement

Global climate change is expected to bring myriad challenges for living systems, including an increase in temperature, heatwaves, more frequent storm events, increased frequency of drought, and decreasing aquatic pH. These changes will happen in concert with other anthropogenic changes, such as habitat loss and pollution. Resource managers will require information about how organisms, communities, and populations are likely to change and adapt, which will be related to their tolerance and phenotypic plasticity, as well as life history and species interactions.

The role for genomics

Across the organisation, CSIRO has developed capacity in genomics (here used to include e DNA, transcriptomics and epigenomics, as well as quantitative genetics and population genomics) that can be applied climate adaptation research. When coupled with our existing strengths in study design, conceptual frameworks and ecosystem modelling, we have an unparalleled capacity to develop predictive monitoring capacity.

The benefits of using the omics based technologies include:

- The ability to measure portions of the ecosystem (e.g. microbial taxa, cryptic taxa) that would otherwise be unaccounted for;
- The ability to measure changes in organism physiology in near real time;
- The ability to identify functional capacity and make predictions about adaptive traits
- The ability to quantify rapid (epigenomic) adaptation
- The ability to get information about how an ecosystem is changing rapidly (e.g. days to months, instead of years) to enable adaptive management frameworks

Specific examples of questions posed by resource managers, and the approaches that could be considered to address them, are provided in the table that follows:

	Environmental Genomics	Biogeochemical Tracers	Coastal Vegetation and Sediment	Coastal Microbiology and Biogeochemistry	MRI – close kin genetics	Environomics FSP (L&W, O&A, NCMI)	Syn Bio FSP (L&W, H&B)	AG &Food	NCMI
How can we measure changes in the community composition of the system?									
Tag sequencing analysis	X		X			X	X		X
Metagenomes & metatranscriptomes	X	X		X		X	X		X
Metazoan eDNA	X		X			X			X
Are organisms of concern adapting to environmental changes? Does it have the capacity to adapt?									
RNA profiling	X					X	X		
Comparative Genomics	X						X	X	
Examine key symbiotic relationships	X								
Epigenomic profiling						X			
Changes in diets	X		X				X		X
Quantitative genetics						X	X	X	
How are organisms of concern changing in response to environmental conditions?									
Comparative Genomics	X	X					X	X	
Stressor response transcriptomic profiles	X	X				X	X		
Epigenomics						X			
Changes (including spatial/temporal variability) in population abundance, demographic parameters etc.	X				X		X		
Changes in larval distribution, diets, disease susceptibility	X		X						X
How can these tools be used in support of assisted evolution and ecosystem restoration?									
Tracking the distribution of farmed/ translocated organisms	X								X
Screening translocated organisms for the adaptive traits		X					X		X
"Probiotic" inoculations to support resilience	X								

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