

Listening to Nature: Techniques for Large-scale Monitoring of Ecosystems using Acoustics

Paul Roe

Micorosoft QUT eResearch Centre

QUT, Brisbane, Australia

p.roe@qut.edu.au



Queensland University of Technology

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- Joint work with: Birgit Planitz, Paul Roe, Jiro Sumitomo, Michael Towsey, Ian Williamson, and Jason Wimmer (Queensland University of Technology)

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The Earth and Us



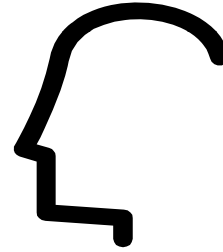
Ecosystem services

Water
Energy
Food, ...



Human impact

Global warming
Pollution
Over population
Land use change,...

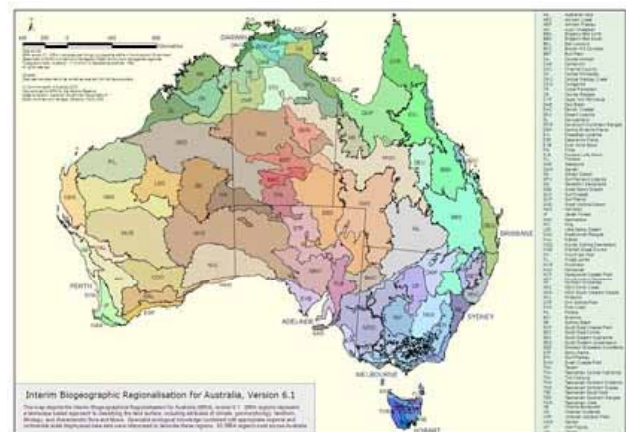


Need to measure environmental 'health'
If you can't measure it – you can't manage it

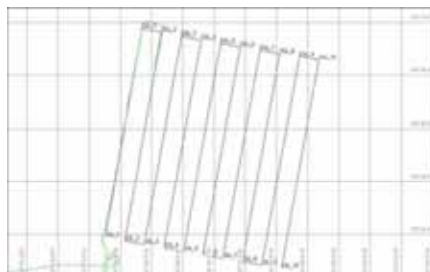
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Assessing Ecological 'Health'

- Australia divided into
 - 14 Ecoregions
 - 85 Bioregions
 - 403 Subregions
- Vegetation Assessments
 - BioCondition (Queensland)
 - Calibrated veg. assessment tool
- Fauna Surveys
 - E.g. Bird point counts & traps
 - Time consuming
 - Expensive
 - Small scale
 - Subjective



<http://www.environment.gov.au/parks/nrs/science/ibra.html>



Assessment manual &
expensive
(except remote sensing)



Idea: Use Sound Collection and Analysis to Scale Fauna Surveys

Environmental acoustics



Environmental health report

- Indicator species
- Migratory species
- Invasive species
- Disturbance

Emulate scientists (eyes and) ears

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Analyses that ecologists might want to undertake using sound

- Species presence/absence
- Species richness/diversity and abundance
- Behavioural studies
- Disturbance
- Environmental health measurement

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Ecosystem Processes and Sensors

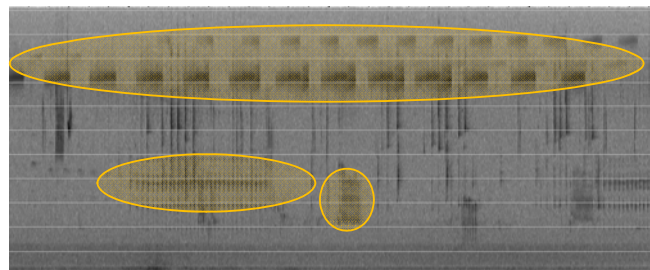
1. Cycling of water
2. Cycling of nutrients
3. Energy transfers
4. Species inc. biodiversity

Traditional sensors:
temperature, water, light etc.

Multimedia sensors: emulate
scientists ears and eyes

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Nature of Sound



Pros

- Wide ranging
- Analysis tractable
- Lots of research into human speech recognition, acoustics
- Distinguish: species, location, behaviour, individual
- Other sounds of interest e.g. weather, human disturbance
- Cost of equipment decreasing – consumer tech.

Cons

- Noise
- Imprecise
- Needs super pre-processing before can analyse (unlike human observations)
- Limited research into acoustics for terrestrial ecological monitoring
- Voluminous & processing intensive
- Not all fauna makes sound
- Variation: time, individuals, species, region, distance, environment, equipment

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Key Challenges

- How to analyse sound?
- How to collect, store and process sound?
 - Distributed
 - Voluminous
 - Processing intensive to analyse

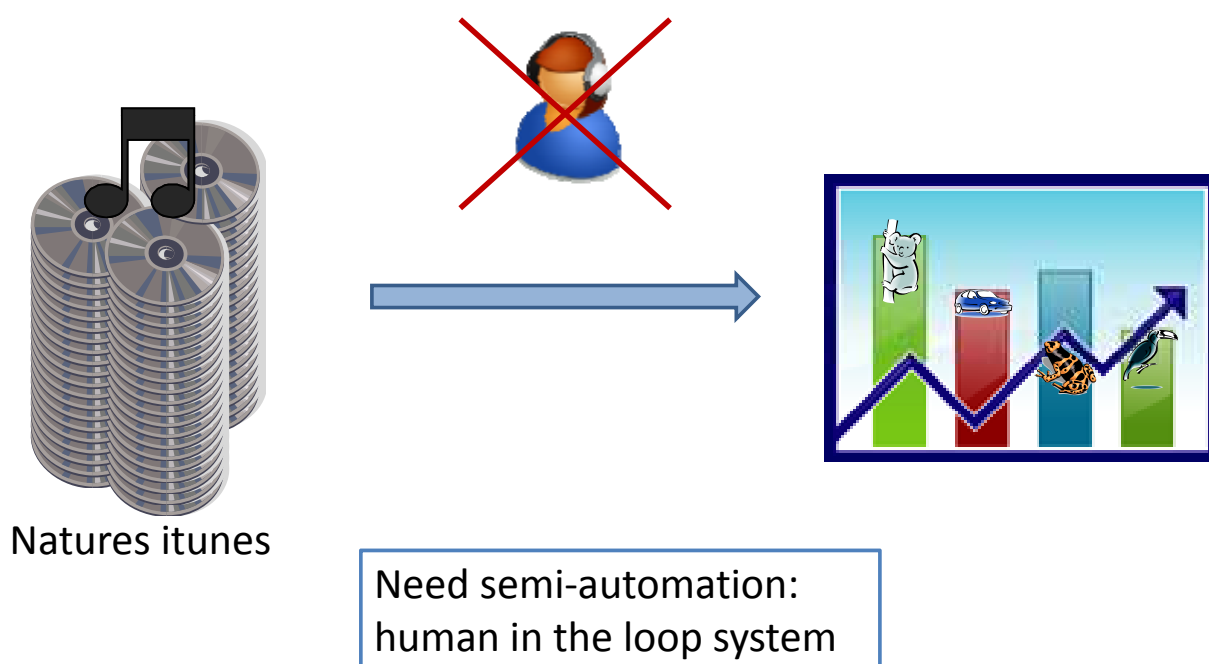
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Our Approach

- Trying to follow Jim Gray e-Science approach
 - Data questions
 - Move from one working system to another
- Pragmatic, applied, scientist driven
- Lo-Fi, consumer h/w (ride commoditisation wave)
- Sound: audible range, not directional, terrestrial
- Toolbox analysis – no single solution
- Trade sensing time for detection accuracy

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Analysis - Data Deluge



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Analysis approaches

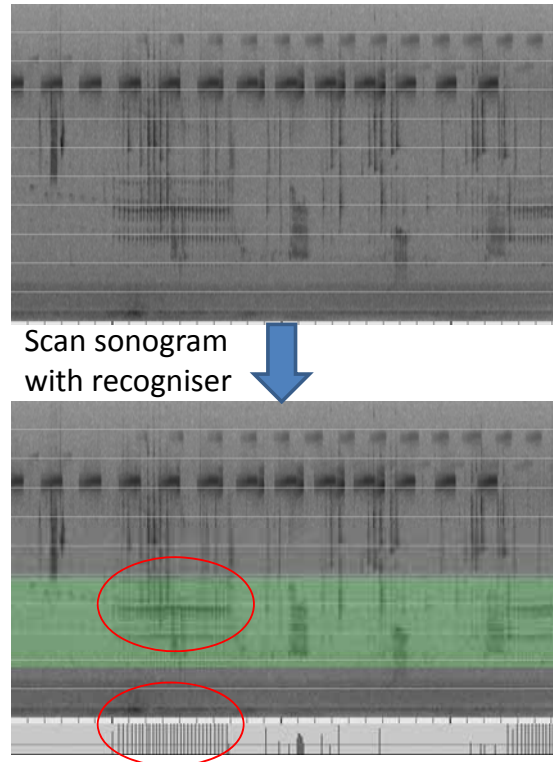
- Manual
 - Listen, filters
 - Visual spectrogram scan (faster than listening)
- Automatic
 1. Template based recognition using speech recognition techniques
 2. Acoustic event detection – image processing on spectrograms
 3. Energy pattern analysis
- *All of the above and more - toolbox*

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1. Template based speech recognition style bird call recognition

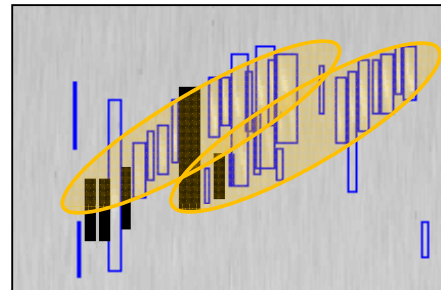
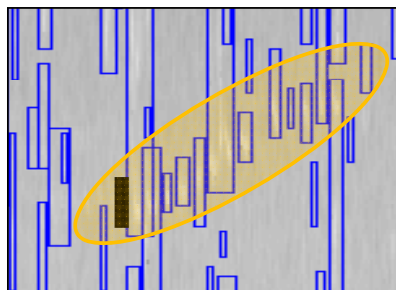
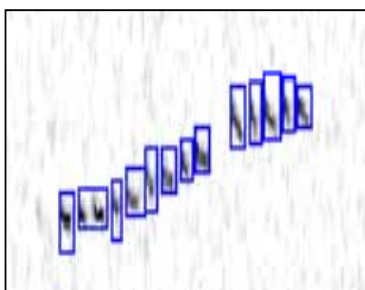
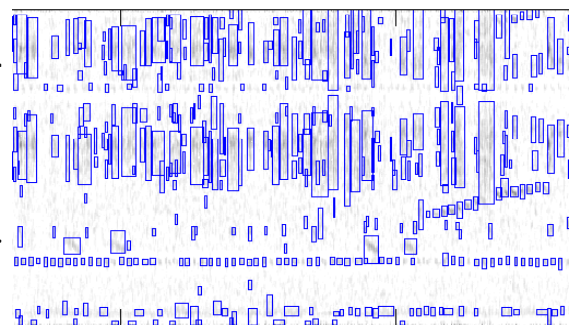
- Steps are described in a template, one template for each call to be recognised.
- Need a library of templates
- Issues:
 - English speech only 50 phonemes
 - Noise unconstrained
 - Need large training sets
 - Contemporaneous acoustic events (not noise)
 - Variability in calls, freq etc.

ASR techniques work for some but by no means all calls



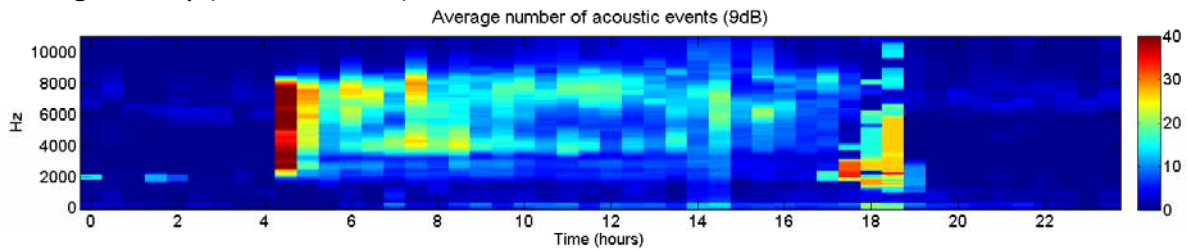
2. Acoustic event detection

- Image processing on spectrograms
- Detect acoustic events, using rectangular windows
- Localised region of high intensity in a spectrogram
- *Good for calls comprising a characteristic pattern of events, broadband or vertical*
- Detect: ground parrots, koalas through patterns of events

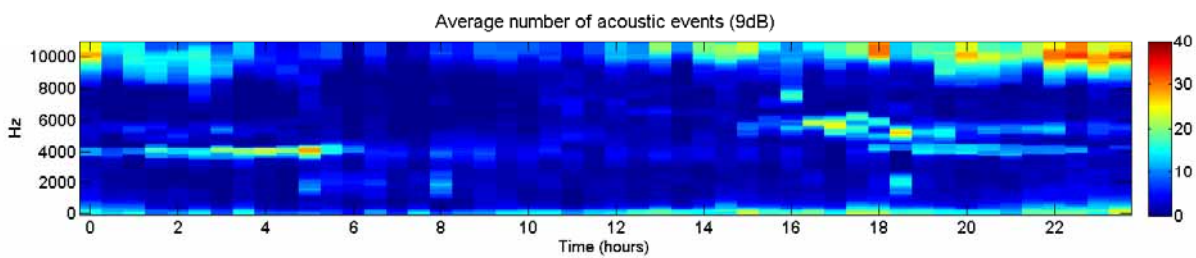


3. Acoustic Landscape using AED

Edge of City (October 2008)

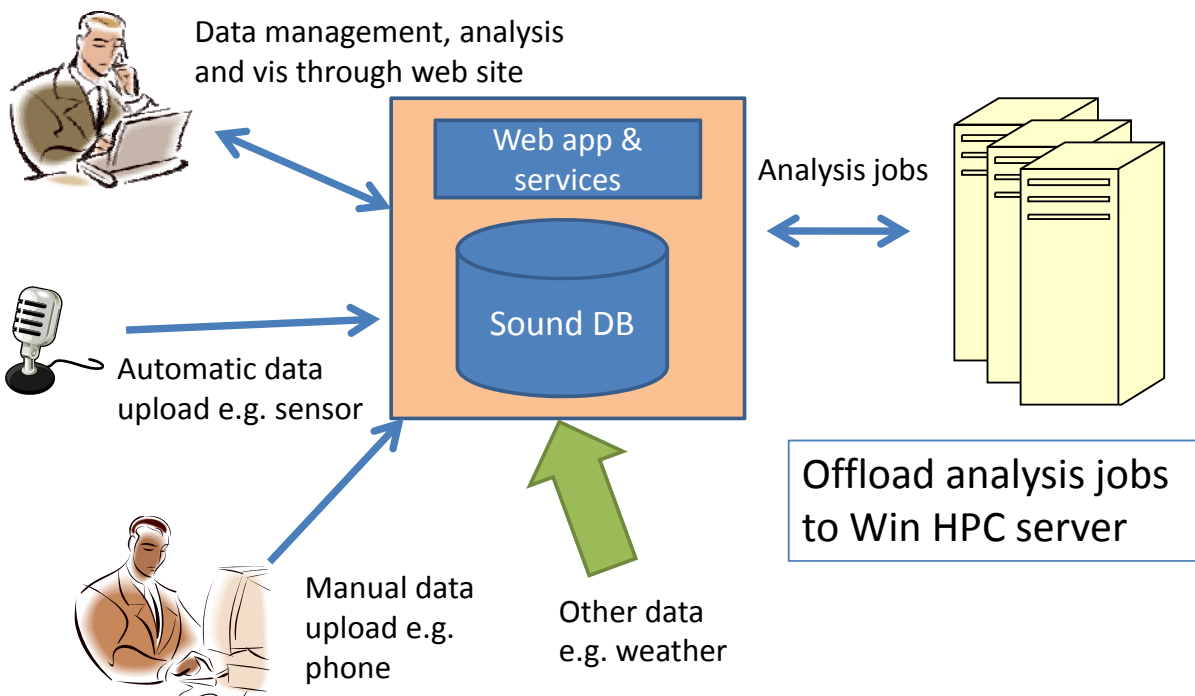


St Bees (October 2008)



Can we correlate with bio-condition indices?

Data Collection and Analysis



Acoustic Sensor = Smartphone + Solar Power + 3G



Commodity technology!

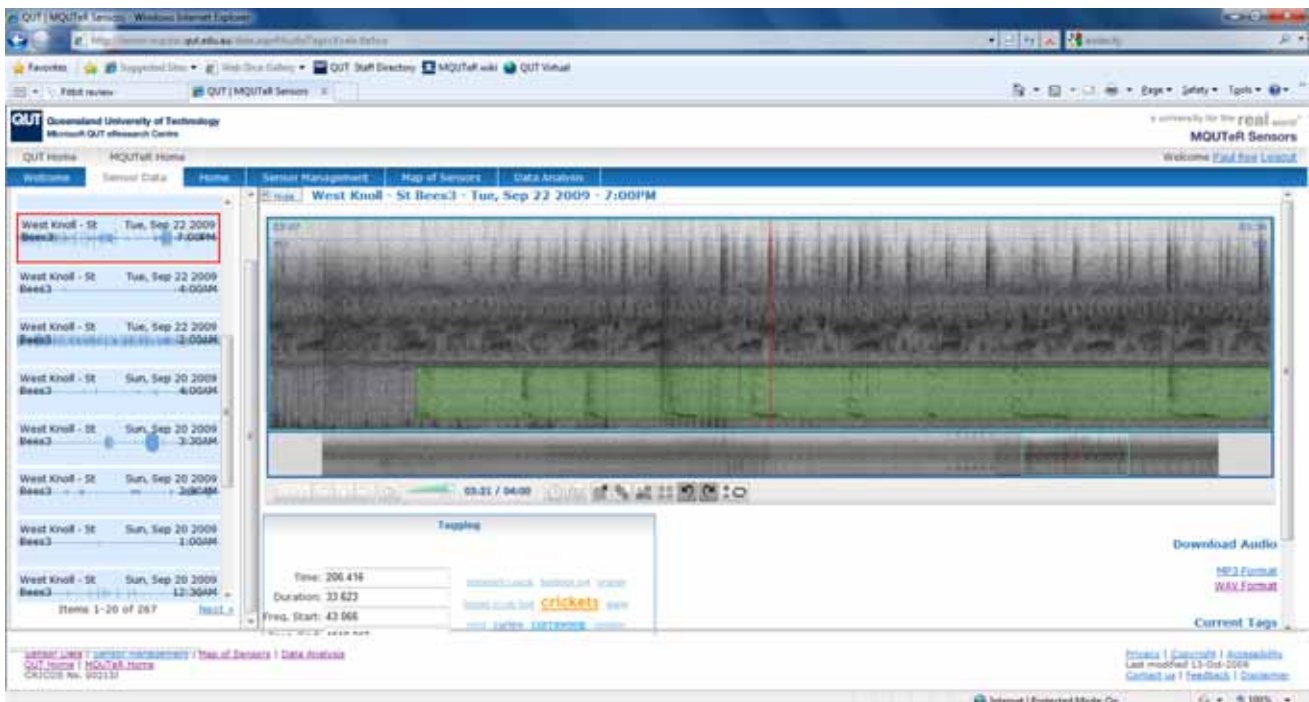


Also manual data upload

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Web Site

- Supports users, projects & sites
- Users can share data & tags
- Create analysis jobs
- Visualise data
- Download csv files – tagged data
- Control and manage sensors



Project: Brisbane Airport & Lewins Rail

- Question: How can a rare cryptic bird be studied which inhabits an access controlled, snake infested area & which is active early morning (e.g. 5am)?
- Solution: research and deploy a wireless acoustic sensor network, collect sensor data and analyse for signs of birds and potential fauna behaviour.
- Where are the Lewin's Rail?

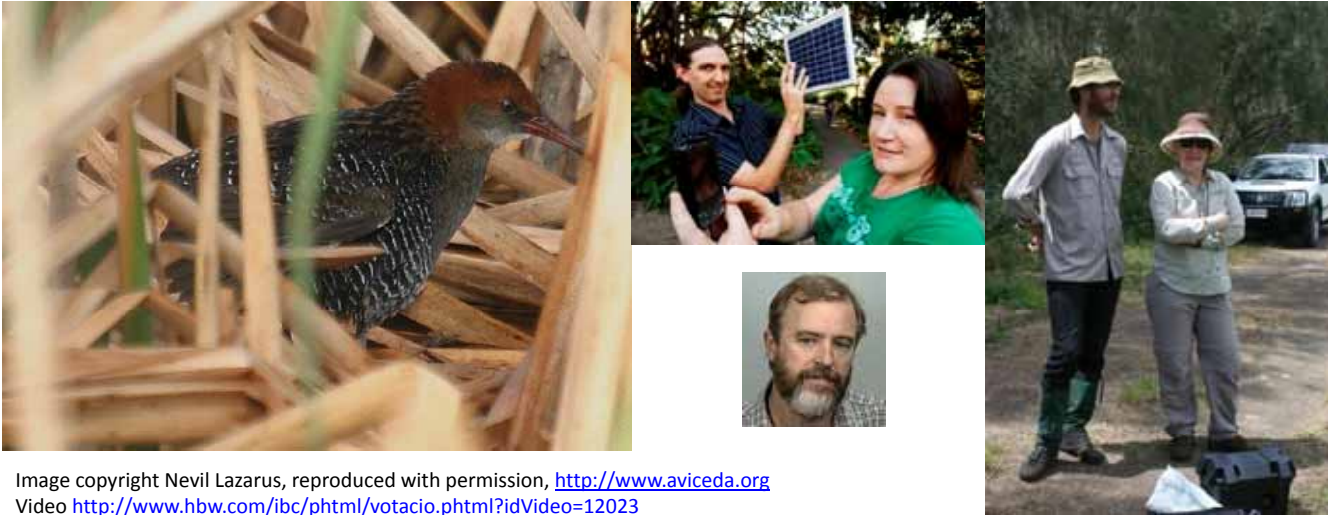


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<http://www.hbw.com/ibc/phtml/votacio.phtml?idVideo=10888>

Project: QUT Samford Ecological Research Facility

- QUT research facility 50Ha – varied environment on outskirts of Brisbane
- Being used to monitor change in the Samford valley
 - The valley is undergoing rapid land use change – adjacent to a large forest park
- Health indices
- Test site



Project: Koala's at St Bees Island

- Question: Why do koala's bellow? By understanding this and other aspects of koalas breeding behaviour koalas may be saved from extinction.
- Solution: research and deploy a wireless acoustic sensor network; collect koala bellowing sounds and correlate with other koala data inc. position from tracking collars.
- Joint work with Dr Bill Ellis @ Uni Queensland



Conclusions

- Researched and deployed a system & analyses – in daily use
- Enabling new science – key to success
- Followed Jim Gray ideas
- Answers to some questions ...
- Is Lewin's Rail present in area X?
 - Yes!
- Do koalas call mostly at dawn and dusk?
 - No! Mostly around midnight!
 - (It appears male koalas are calling to attract females.)
- Feedback for human in loop system
- Ecological validity?
- Bio-condition monitoring?
- Project web site and online tools www.mquter.qut.edu.au/sensor/

Thanks, Plugs and Questions?

- Plugs - conferences
 - Dec 7-9, IEEE e-Science 2009, Oxford UK
 - Dec, 2010, IEEE e-Science 2010, Brisbane, Australia

Microsoft
Research

 **Queensland Government**
State Development

BAC
Australia



CONSERVATION *and* RESEARCH
for ENDANGERED SPECIES

Telstra