Australian Government
Department of the Environment, Water, Heritage and the Arts

Marine and Tropical Sciences Research Facility Milestone Report, June 2010

Program 2: **Status and Trends of Species and Ecosystems of the Wet Tropics**

Project 1.2.1: **(Extension b) Biodiversity monitoring for climate change**

Project Leader: **Associate Professor Steve Williams, James Cook University**

Summary

Here, we report on fauna and weather station monitoring data collected under MTSRF Project 1.2.1 Extension (b). This data has served as a foundation for much of the scientific output in MTSRF Project 2.5ii.4 and, to a lesser extent, other projects. Microclimate data was collected from a region-wide network of 25 weather stations for the period 2006-2010. This data has be used to develop more realistic estimates of microclimate exposure for the region and to identify cool landscape refugia and major microhabitat features that buffer exposure to extreme temperatures. Vertebrate fauna data includes an additional 917 standard surveys and approximately 55,000 individual records. This data has been used to evaluate vulnerability or resilience of species to extinction, evaluate the biodiversity values of climate change refugia, and improve niche models. Invertebrate data has contributed to status and trends of insect diversity (MTSRF Project 1.2.1 Extension d) and has provided the foundations for several PhD projects. We also identify key data sets that will be useful for the detecting change in the status of species in the future.

Project Results

Description of the results achieved for this milestone

1. **Summarise three years' daily weather data from 25 rainforest weather stations deployed and maintained under the project (2006-2009).**

   Microclimate data from 25 rainforest weather stations has been summarised and monthly statistics provided for mean minima and maxima air temperature, soil temperature and relative humidity for the period 2006-2010.

2. **Provide weather station temperature and humidity data to Michael Hutchinson (Centre for Resource and Environmental Studies, Australian National University). Additional data will fill gaps in the regional weather station network and contribute to the generation of improved regional climate layers via future reruns of ANUCLIM.**

   A summary of the above weather station temperature and humidity data has been provided to Michael Hutchinson (Centre for Resource and Environmental Studies at the Australian National University).

3. Provision of regional coverage of microclimate to e-Atlas (a feedback from MTSRF Project 2.5ii.4 Objective d).

Regional coverage of air temperature from MTSRF Project 2.5ii.4 has been uploaded into the e-Atlas (MTSRF Project 1.1.5) along with relevant metadata.

Summary:

Spatial surface of maximum temperature of the warmest period (i.e. month) for the Wet Tropics bioregion taking into account multiple factors that can act to ameliorate temperature including elevation, foliage cover and distance from the coast. Spatial resolution of surface is approximately 80m x 80m. Models were generated from weather station data for each month for the period January 2007 to December 2008. The 24 monthly surfaces were then overlaid and the maximum model temperature for any month was determined for each pixel to generate a summary variable – maximum temperature of the warmest period (i.e. month). A detailed description of data and methods are provided in:

Shoo, L.P., Storlie, C., VanDerWal, J., Little, J., Williams, S.E. (2010) Targeted protection and restoration to conserve tropical biodiversity in a warming world. *Global Change Biology* [doi: 10.1111/j.1365-2486.2010.02218.x]

4. Final report on fauna monitoring and how vertebrate and invertebrate data has been utilised within the MTSRF and other related projects.

Vertebrate and invertebrate monitoring data as well as weather station data has underpinned a large body of research completed within multiple MTSRF and related projects. Each of these is addressed in turn below.

MTSRF Projects:

Vertebrate and invertebrate monitoring data

Vertebrate data has served as a foundation for much of the scientific output in MTSRF Project 2.5ii.4. This includes:

- Evaluating vulnerability or resilience of species to extinction (see Isaac *et al.* 2009; Shoo *et al.* 2009; VanDerWal *et al.* 2009b; Williams *et al.* 2009);
- Evaluating the biodiversity values of climate change refugia (see Shoo *et al.* 2010); and
- Improving niche models (see VanDerWal *et al.* 2009a).

Invertebrate data has contributed to status and trends of insect diversity (MTSRF Project 1.2.1d) and has provided the foundations for several PhD projects (see *Other Related Projects*, following page).

Outputs/Publications:

Isaac, J. L., VanDerWal, J., Johnson, C. N. and Williams, S. E. (2009) Resistance and resilience: Quantifying relative extinction risk in a diverse assemblage of Australian tropical rainforest vertebrates. *Diversity and Distributions* 15(2): 280-288.

Shoo, L. P., Anderson, A. and Williams, S. E. (2009) On the isolated population of Lewin's Honeyeater (*Meliphaga lewinii amphochlora*) from the McIlwraith Range uplands, Cape York Peninsula, Australia: Estimates of population size and distribution. *Emu* 109(4): 288-293.

Shoo, L. P., Storlie, C., VanDerWal, J., Little, J. and Williams, S. E. (2010) Targeted restoration to conserve tropical biodiversity in a warming world. *Global Change Biology* [doi: doi:10.1111/j.1365-2486.2010.02218.x]

VanDerWal, J., Shoo, L. P., Graham, C. and Williams, S. E. (2009a) Selecting pseudo-absence data for presence-only distribution modeling: How far should you stray from what you know? *Ecological Modelling* 220: 589-594.

VanDerWal, J., Shoo, L. P., Johnson, C. N. and Williams, S. E. (2009b) Abundance and the environmental niche: Environmental suitability estimated from niche models predicts the upper limit of local abundance. *American Naturalist* 174(2): 282-291.

Williams, S. E., VanDerWal, J., Isaac, J., Shoo, L. P., Storlie, C., Fox, S., Bolitho, E., Moritz, C., Williams, Y. and Hoskin, C. (In press) Distributional, life history characteristics, ecological specialization and phylogeny of the rainforest vertebrates in the Australia Wet Tropics bioregion. *Ecology (Data Paper)*.

Williams, S. E., Williams, Y. M., VanDerWal, J., Isaac, J. L., Shoo, L. P. and Johnson, C. N. (2009) Ecological specialization and population size in a biodiversity hotspot: How rare species avoid extinction. *PNAS* 106: 19737-19741.

Weather station data

Information from weather stations has been integral to subproject MTSRF Project 2.5ii.4 concerned within identifying cool landscape refugia and major microhabitat features that buffer exposure to extreme temperatures (Shoo *et al.* 2010a, 2010b). This information has also been used in another subproject evaluating the physiological tolerances of threatened species (Andres Merino-Viteri, PhD Thesis).

Outputs/Publications:

Shoo, L. P., Storlie, C., VanDerWal, J., Little, J. and Williams, S. E. (2010a) Targeted restoration to conserve tropical biodiversity in a warming world. *Global Change Biology* [doi: doi:10.1111/j.1365-2486.2010.02218.x]

Shoo, L. P., Storlie, C., Williams, Y. M. and Williams, S. E. (2010b) Potential for mountaintop boulder fields to buffer species against extreme heat stress under climate change. *International Journal of Biometeorology* [doi: 10.1007/s00484-009-0286-4]

Other Related Projects:

Vertebrate and invertebrate monitoring data

Behavioural data collected during field surveys has provided new insights into the natural history of poorly known species (Anderson *et al.*, In press). Genetic analysis of animal tissue collected during field surveys has identified suture zones – shared regions of secondary contact between long-isolated lineages – that are natural laboratories for studying divergence and speciation (Moritz *et al.* 2009). Current students within the Centre for Tropical Biodiversity and Climate Change, James Cook University, are utilising fauna monitoring data to:

- Evaluate energy constraints on birds (Alex Anderson, PhD Thesis);
- Relate patterns of net primary productivity to biodiversity (Vanessa Valdez Ramirez, PhD Thesis);

- Determine the potential for invertebrates to serve as indicator taxa for biodiversity (Marios Aristophanous, PhD Thesis);
- Evaluate the effects of cyclone disturbance on fly communities (Rohan Wilson, PhD Thesis); and
- Relate parasite loads to distribution patterns of birds (Itzel Zamora Vilchis, PhD Thesis)

Outputs/Publications:

Anderson, A., Monasterio, C. and Shoo, L. P. (In press). Breeding behaviour of the poorly known Australian hylid frog *Litoria longirostris*. *Herpetofauna*.

Moritz, C., Hoskin, C. J., MacKenzie, J. B., Phillips, B. L., Tonione, M., Silva, N., VanDerWal, J., Williams, S. E. and Graham, C. H. (2009). Identification and dynamics of a cryptic suture zone in tropical rainforest. *Proceedings of the Royal Society B: Biological Sciences* 276: 1235-1244.

Weather station data

Weather data has been used to better understand regional patterns and controls of leaf decomposition and nutrient dynamics within rainforest (Scott Parsons, PhD Thesis).

Outputs/Publications:

Parsons, S., Congdon, R. A., Lawler, I. R., Shoo, L. P. and Williams, S. E. (In review) Regional patterns and controls of leaf decomposition and nutrient dynamics in Australian tropical rainforests. *Oecologia*.

5. Summarise the extent of baseline data set accumulated for rainforest fauna and identify key areas (taxonomic groups, locations of intensively sampled sites) where data set will be most amenable to the detection of change in the status of species in the future.

Baseline data set

MTSRF Project 1.2.1(b) supported an extensive field research program to generate new abundance information and occurrence records for vertebrate and invertebrate species.

Species abundances were estimated from taxon-appropriate standardised survey methods that have been employed across the region since 1992. Details of the survey methods are described in VanDerWal *et al.* (2009) (*The American Naturalist* 174(2): 282-291) and repeated below under *Protocols for individual sampling techniques*. Most surveys were conducted in rainforest within the Australian Wet Tropics (AWT) but components of the data collection program (primarily birds) extended to central-east Queensland (CEQ) and Cape York Peninsula (CYP).

Surveys within the AWT largely focused on 25 long-term monitoring sites established by the Centre for Tropical Biodiversity and Climate Change. These sites coincide with the 25 weather station locations described above. Exceptions included targeted gap filling surveys of birds in the Ingham and Daintree lowlands, microhylid surveys on Mount Elliot (*Cophixalus mcdonaldi*) and Thornton Peak (*Cophixalus concinnus*) and a full complement of vertebrate surveys at the TERN long term monitoring plot in Lamb Range.

The baseline data set of standard surveys is a valuable complement to previous data we have collected for the region including 1,387 bird surveys, 449 spotlight surveys, 1,169 reptile surveys, 131 stream frog surveys, 614 microhylid frog transect surveys and 445 microhylid frog point surveys.

The project also delivered more than 54,500 new occurrence records. Most of these were derived from standard surveys within the AWT but also include valuable comparative records of more northerly and southerly fauna.

Detection of change in the status of species in the future

Likely candidate study data sets for detecting future change in the status of species include:

- A fifteen-year repeat census of arboreal mammals at high elevation rainforest near Ravenshoe;
- Ongoing monitoring of the Carbine population of the Lemuroid Ringtail Possum (*Hemibelideus lemuroides*); and
- A nineteen-year data set of standardised bird surveys across environmental gradients in the Wet Tropics.

Protocols for individual sampling techniques

<u>Bird surveys</u> consisted of walking for exactly thirty minutes along a 150m transect (measured using a hip chain) through the rainforest, using both visual observations and bird calls to identify species. Only calls made within fifty metres of the transect line were recorded. As much care was taken as possible to avoid double-counting of calling individuals. Surveys were conducted only if environmental conditions on the sampling day were suitable enough to ensure that daily conditions did not bias the results. For example, no surveys were conducted in rain or strong winds.

<u>Spotlight surveys</u> were nocturnal visual and acoustic counts of mammals, geckos, frogs and nocturnal birds from 1,000m transects along old unused logging tracks, with one hectare of search effort, using a combination of one observer with a 30 watt handheld spotlight and another observer with a low-power head torch. This combination maximises efficiency, as the powerful spotlight is best for detecting arboreal mammals and owls, while the low-power head torch is better for detecting geckos and frogs.

<u>Reptile surveys</u> were counted during one person-hour, and the search was restricted to a fifty-metre radius of active diurnal examination of the forest floor and vegetation, as well as shelter sites, such as under logs. Surveys were conducted only under warm (air temperature, >22°C) or sunny conditions and never during rain. Sampling criteria were based on regression tree analysis of reptile abundance and environmental conditions (S. E. Williams, unpublished data).

<u>Stream-frog surveys</u> consisted of a 200m nocturnal transect along rain forest streams. All individuals were located and identified visually (usually by eye-shine reflection) and/or acoustically (by call). Counts were made of any individual located within the stream itself or along adjacent streamside embankments.

<u>Microhylid frog transect surveys</u> consisted of a nocturnal, slow-paced walk (~10 minutes' duration) along a fifty-metre transect through rainforest. All calls were identified to species,

and counts were made of number of individuals calling within ten metres on either side of the transect. Because detection probability was dependent on calling males, surveys were timed to coincide with known months of breeding. In all, 25 of the 27 dated breeding records compiled for microhylid species in the region are from the late dry to the early wet seasons (Hoskin 2004). Surveys for microhylid species were thus exclusively confined to this time period. Surveys were also conducted only on wet, humid nights (>80% relative humidity).

Microhylid frog point surveys were open ended counts of all calling males from fixed locations usually conducted in conjunction with spotlight surveys and not restricted to any particular time of year.

6. Comment on future extensions for research completed under MTSRF Project 1.2.1(b)

Real world case studies of biological responses to extreme weather

Little is known about the vulnerability of diverse tropical rainforest systems to extreme weather events. A potential example of the vulnerability of tropical biota to extreme events is the recently observed severe decline in the Carbine population of the Lemuroid Ringtail Possum (*Hemibelideus lemuroides*) in the Wet Tropics. Targeted monitoring of this population has been made possible as part of MTSRF Projects 2.5ii.4 and 1.2.1. Only three individuals (all at one locality on one night) have been seen in three years. This apparent precipitous population decline has been linked to increasing frequency and intensity of chronic heat wave events with the most severe occurring in late 2005.

There is considerable scope to utilise and extend the data set from MTSRF Project 1.2.1 to quantify stress on tropical terrestrial rainforest biota associated with extreme weather events. Firstly, this could be achieved by mining our extensive survey data base and identify key locations and taxa where we have long-term count data and/or high frequency of repeat count surveys over time periods that have encompassed extreme weather events. It would then be possible to complement this data set with targeted surveys at select locations to update counts. Extreme weather events could be identified using a combination of recently available spatial layers of daily rainfall and maximum temperature for the period 1950 to present (derived from the Australian Water Availability Project, http://www.bom.gov.au/jsp/awap/) and sophisticated analytical tools grounded in extreme value theory [e.g. Extremes Toolkit (extremes) developed by NCAR Weather and Climate Impact Assessment Science Initiative] and ground-truthed with weather station data.

It would then be possible to combine count data and weather data to quantify population declines and recovery rates immediately following extreme events. This would allow us to move beyond predictions of vulnerability and provide much needed empirical case studies of impacts and recovery based on real data. Likely candidate study data sets include:

- A fifteen-year repeat census of arboreal mammals at high elevation rainforest near Ravenshoe;
- Ongoing monitoring of the Carbine population of the Lemuroid Ringtail Possum (*Hemibelideus lemuroides*); and
- A nineteen-year data set of standardised bird surveys across environmental gradients in the Wet Tropics.

Evaluating the functional benefits of existing and restored refugia

MTSRF Projects 2.5ii.4 and 1.2.1b identified priority areas for protection and restoration of cool rainforest refugia. Additionally, MTSRF Projects 4.9.5 valuated the time taken for restoration plantings to recover forest structure and biodiversity values. There is a valuable opportunity to build on this work by addressing two key questions. First, what is the existing population size of target taxa in fragmented refugia? Second, how long does it take to re-establish microclimate buffering of forest under different restoration strategies (e.g. ecological plantings, plantings for carbon and natural regrowth)?

The first question would involve targeted vertebrate surveys in existing fragments of cool refugia both within the protected area network and on candidate freehold land where property owners have expressed interest in entering into a Refuge Area Agreement. This would yield critical information on population viability of vulnerable taxa within existing fragments and evaluate the benefit of Refuge Area Agreements in securing viable populations.

The latter question could be addressed by deploying a supplemental array of data loggers in different aged restoration plots and quantifying buffering of temperature and other microclimate variables. This ground-truthing will be highly instructive in providing conservation planners with critical information to assess trade-offs between different restoration strategies (time and cost) to maximise conservation outcomes and make a case for a geographically expanded application of the model across other rainforest systems in eastern Australia.

Additional strategic gap-filling

- <u>Environmental gaps:</u> Fauna surveys in climatic space previously not sampled to improve the generality and robustness of models on impacts and improve basic distributional data on many species. For example, hot, seasonal rainforests with conditions analogous to that expected to become more widespread under future climate change could be targeted.
- <u>Geographic:</u> Current research has highlighted several geographic areas that may be important gaps in our current biodiversity information (e.g.,areas of high endemism).
- <u>Habitats:</u> Wet sclerophyll, coastal mosaic. Increased coverage of undersampled habitat types in the region.
- <u>Cape York:</u> Expansion of the bird monitoring being conducted on Cape York.
- <u>Eungella:</u> Expansion of the bird monitoring being conducted on Eungella (mid-east Queensland).
- <u>Lamington:</u> Extension of the latitudinal gradient of faunal sampling to include the most southern blocks of rainforest in the State.
- <u>Western Outliers:</u> Including fauna surveys in riparian gallery forests.

7. Attribution of MTSRF funding in all products

Fauna and weather station monitoring data has served as a foundation for much of the scientific output in MTSRF Project 2.5ii.4. The MTSRF has been acknowledged in all products arising directly (see above) and indirectly (see final report on MTSRF Project 2.5ii.4) from MTSRF Project 1.2.1b. This includes: 18 (12 more in review) publications; 7 magazines and newsletters; 22 conference presentations; eight conference poster presentations; and four workshops.