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

Marine and Tropical Sciences Research Facility Milestone Report, March 2009

Program 5ii: Climate Change: Rainforests and Catchments

Project 2.5ii.4: Impacts of climate change on biodiversity

Project Leader: Associate Professor Steve Williams, James Cook University

Summary

This project continues to remain on track and is progressing well. For this March milestone report, analyses have shown that long-term habitat stability and short-term climate stability are important predictors of patterns of species richness. This has implications for maintenance of biodiversity under increasingly variable climates.

There has continued to be progress investigating landscape features that can provide unusually buffered environments both now and in the future. We have successfully trialled a new approach to indirectly estimate patterns of cloud across the region using satellite data on solar radiation. Cloud has the potential to reduce the diurnal temperature range in some forests by moderating exposure to solar radiation. This information is already being fed back into analyses to generate regional maps describing thermal buffering due to complex topography.

There has been a critical appraisal of approaches used to estimate forest primary productivity at regional scales. This appraisal has been useful in identifying shortcomings in previous studies that will be addressed in our own research that aims to scale up field estimates of forest primary productivity to inform regional questions such as: where are the most productive areas of rainforest and will the pattern of productivity change under future climate?

The next milestones report will include a report on field measurements of physiological tolerances of microhylid frogs, production of regional GIS coverage of microclimate and comparison of spatial predictions of Net Primary Productivity.

Project Results

Description of the results achieved for this milestone

1. **Analysis of the relationship between historical climate conditions, habitat and current patterns of biodiversity. Use past climate change to make better predictions of future biodiversity, i.e. what can the past tell us about extinction dynamics to allow better predictions about the future? [Objectives (a) and (b)]**

   Of the many hypotheses proposed to account for large-scale patterns of species richness, it is widely believed that some aspect of contemporary climate (precipitation, temperature, net primary productivity, etc.) ultimately controls large-scale patterns of species richness. However, historical factors, such as fluctuations in habitat associated with quaternary climate fluctuations, have been shown to improve our understanding of biogeography, evolutionary dynamic and patterns of biodiversity.

We proposed that stability in terms of long-term habitat and short-term climate can explain much of the patterns of diversity in the Australian Wet Tropics (AWT). Total and taxon-specific species richness estimates were created based on overlapping modelled distributions of vertebrate rainforest species. Habitat stability estimates were based upon rainforest stability since the lat glacial maximum and climatic means and stability (temperature and precipitation) was estimated using Anuclim. Long-term habitat and short-term climate stability generally explained nearly the same amount of variation in species richness with contemporary climate means being the best predictor. The best regression models were often the models that include aspects of historical habitat stability and both contemporary climate means and stability. These models were able to explain up to 75% of the variation in species richness.

This has important implications with respect to climate change. While the climate projections for the AWT suggest that temperature will increase and precipitation may or may not change, the seasonality of both is projected o dramatically increase. The stability of the habitat (e.g. long time lag associate with shifting vegetation) may be able to mitigate some of the immediate changes in climate.

Results have been presented at the 2008 MTSRF Annual Conference in Cairns and the Ecological Society of Australia 2008 Conference in Perth: VanDerWal, J., Shoo, L.P. and Williams, S.E. (2008) *Stability begets diversity: patterns of rainforest vertebrate diversity in Australia's Wet Tropics in light of long term habitat and short term climatic stability patterns*.

2. Regional maps describing thermal buffering due to complex topography (e.g. gorges and steep slopes) [Objective (c)]

The aim of this project is to identify landscape features that can provide unusually buffered environments both now and in the future. This will provide decision support information for managers to direct resources toward natural refuges that will maximize longer-term conservation outcomes. To date, models of organism exposure to stressful climatic conditions have relied on simplistic interpolations of temperature and precipitation. These models do not adequately consider some important processes that can act to moderate local climate. To this end, we are interrogating additional physical processes that serve to mediate temperature in rainforests across complex terrain and that will allow us to generate regional maps of thermal buffering. The project integrates spatial analysis of remote sensing data (i.e. satellite information) with detailed measurement of meteorological conditions in the field.

Data on mean maximum and minimum monthly temperatures has now been compiled from 25 weather stations maintained in the field from November 2006 to present. We are in the final stages of generating spatial layers of independent variables that will be incorporated into models to explain variation in temperature. Completed layers include distance to major drainage line (a surrogate for cold-air drainage that influences minimum temperature), distance to coast (high humidity close to ocean can reduce diurnal temperature range), and clear-sky solar radiation (influences daytime maximum temperatures).

Layers yet to be completed include realised solar radiation and foliage projection cover. Realised solar radiation will take into account real-time attenuation of radiation due to cloud. The effect of cloud is expected to be important in reducing the diurnal temperature range in mountainous areas that are frequently inundated by cloud. Spatial layers are being derived using recently available data on daily solar exposure generated by the Bureau of Meteorology from geostationary satellites. The method has been successfully trialled for the month of January across the available data collection period for satellites (1990-2008). A complete set of layers for all months is expected to be finalised before the next reporting period. Finally, foliage projection cover (i.e. canopy cover) is expected to be an additional factor mediating ambient temperatures in rainforests (via filtering of direct solar radiation during the day and insulation against temperature loss at night). We have used canopy photographs to quantify canopy openness above weather stations. However, a continuous spatial layer for the region is required for the project. We are currently in discussion with the Queensland Department of Natural Resources and Water to acquire foliage projection cover data generated from Landsat imagery as part of the Statewide Landcover and Trees Study (SLATS).

3. Compilation of metadata on empirical net primary productivity (NPP) from published studies within tropical forests and review data gaps and shortcomings of existing algorithms used to predict NPP [Objective (d)]

We compiled a consolidated data set on empirical net primary productivity for global tropical forests. This brought together information from 37 forest plots. These were:

- **Islands** – Upland Hawaii – Twelve plots from a precipitation gradient on Maui (Schuur and Matson 2001); an elevational gradient on Mauna Loa (Sites 5 and 6 in Raich *et al.* 1997) and a chronosequence of older soils from Laupahoehoe, Kohala, Kolekole and Kokee (Herbert and Fownes 1999);
- Upland Borneo – Twelve plots from an elevational gradient established on Mount Kinabalu, Malaysia (Kitayama and Aiba 2002) plus Q, T, U ridge and U lower slope in Takyu *et al*. 2003;
- Lowland Borneo – Three habitats on different parent material (each an average across plots) west Kalimantan, Indonesia (Paoli and Curran 2007);
- **Continents** – Lowland South America – six plots from a collection of neotropical studies undertaken at San Carlos terra firme and San Carlos caatinga (Cuevas and Medina 1986, Malhi *et al.* 2004), BDFFP Fazenda Dimona (Malhi *et al*. 2004, interior plots in Sizer *et al*. 2000), Tapajós Brazil (control plot in Nepstad *et al*. 2002), Paragominas Brazil (J. Chambers and D. Nepstad *pers. comm*. in Clark *et al*. 2001);
- Upland South America – one habitat (average across plots) from Porce Colombia (Sierra *et al*. 2007);
- Lowland North America – three plots from Chamela, Mexico (Martinez-Yrizar *et al.* 1996); and
- Lowland Asia – One plot from Pasoh Malaysia (Kira 1978).

For consistency, it was assumed that dry mass of vegetation was on average 50% C allowing productivity to be reported in the units Mg C ha^{-1} y^{-1}.

Table 1: Metadata on empirically measured net primary productivity from global tropical forests. Litter: fine-litter production (leaves, fruit, flowers, small twigs, but excluding coarse woody debris); ABI: annual above-ground biomass increment (forest wood production) in the units Mg C ha^{-1}. Groups were delineated geographically by landmass (continents and islands) and environmentally by elevation (i.e. above or below five hundred metres asl) to reflect differences in species composition between landmasses and structural characteristics and growth form between upland and lowland tropical forests.

No.	Plot	Group	Label	ABI	Litter
1	Brazil: Fazenda Dimona (BDFF)	Lowland South America	lsa	2.40	3.52
2	Brazil: Paragominas	Lowland South America	lsa	1.30	4.60
3	Brazil: Tapajos 1-4, 5-8, 9-12 (TAP01,02,03)	Lowland South America	lsa	2.78	3.08
4	Venezuela: San Carlos terra firme	Lowland South America	lsa	1.76	5.13
5	Venezuela: San Carlos tall caatinga	Lowland South America	lsa	1.53	2.81
6	Malaysia, Kinabalu, S1700	Upland Borneo	ub	2.12	4.00
7	Malaysia, Kinabalu, S2700	Upland Borneo	ub	1.24	2.66
8	Malaysia, Kinabalu, S3100	Upland Borneo	ub	0.93	3.16
9	Malaysia, Kinabalu, S700	Upland Borneo	ub	4.02	5.50
10	Malaysia, Kinabalu, U1700	Upland Borneo	ub	0.93	3.14
11	Malaysia, Kinabalu, U2700	Upland Borneo	ub	0.66	2.97
12	Malaysia, Kinabalu, U3100	Upland Borneo	ub	0.16	0.82
13	Malaysia, Kinabalu, U700	Upland Borneo	ub	3.01	5.57
14	Malaysia: Mt Kinabalu, Q Ridge	Upland Borneo	ub	0.30	2.70
15	Malaysia: Mt Kinabalu, T Ridge	Upland Borneo	ub	0.70	3.95
16	Malaysia: Mt Kinabalu, U Lower slope	Upland Borneo	ub	0.95	3.30
17	Malaysia: Mt Kinabalu, U Ridge	Upland Borneo	ub	0.45	2.10
18	USA, Hawaii, MAP = 2200 mm	Upland Hawaii	uh	0.40	4.30
19	USA, Hawaii, MAP = 2450 mm	Upland Hawaii	uh	0.30	5.00
20	USA, Hawaii, MAP = 2750 mm	Upland Hawaii	uh	0.70	4.20
21	USA, Hawaii, MAP = 3350 mm	Upland Hawaii	uh	0.20	4.45
22	USA, Hawaii, MAP = 4050 mm	Upland Hawaii	uh	0.90	2.88
23	USA, Hawaii, MAP = 5050 mm	Upland Hawaii	uh	0.10	1.95
24	USA: Hawaii (Kohala)	Upland Hawaii	uh	1.35	3.23
25	USA: Hawaii (Kokee)	Upland Hawaii	uh	1.98	2.08
26	USA: Hawaii (Laupahoehoe)	Upland Hawaii	uh	2.08	2.71

No.	Plot	Group	Label	ABI	Litter
27	USA: Hawaii (Puu Kolekole)	Upland Hawaii	uh	2.60	4.38
28	USA: Hawaii, Site 5 (3400 yr, 700 m)	Upland Hawaii	uh	0.30	4.16
29	USA: Hawaii, Site 6 (3400 yr, 1660 m)	Upland Hawaii	uh	0.45	2.46
30	Paoli ALLUVIUM	Lowland Borneo	lb	8.01	4.37
31	Paoli SEDIMENTARY	Lowland Borneo	lb	5.16	3.92
32	Paoli GRANITE	Lowland Borneo	lb	4.90	3.38
33	Porce Colombia	Upland South America	usa	6.82	5.24
34	Pasoh Malaysia	Lowland Asia	la	2.70	5.30
35	Chamela Mexico lower	Lowland North America	lna	1.45	2.11
36	Chamela Mexico middle	Lowland North America	lna	1.14	1.60
37	Chamela Mexico upper	Lowland North America	lna	1.00	1.65

A review of data gaps and shortcomings of existing algorithms used to predict NPP has been completed. This was done in two parts; first, we used our compiled metadata to demonstrate that there are no shortcuts to indirectly estimate major components of NPP that are not measured directly in the field. We recommend that algorithms only be developed using data from plots where all major components of NPP have been directly measured in the field.

For further details see: Shoo, L.P. and VanDerWal, J. (2008) No simple relationship between aboveground tree growth and fine-litter production in tropical forests. *Journal of Tropical Ecology* 24, 347-350

Second, we focused on the most recent attempt to establish a global relationship between climate and NPP [Del Grosso *et al.* (2008) Global potential net primary production predicted from vegetation class, precipitation, and temperature. *Ecology* 89:2117-2126] and describe two main methodological issues that are typically inherent in these sorts of analyses. Specifically: (1) much of the data used to parameterise models are not independent; and (2) no attempt is made to account for significant temporal variability in climate that is likely to have affected observed productivity and hence inferred relationships between NPP and climate. Our review is currently in submission to *Ecology*.

Shoo, L.P. and Valdez Ramirez, V. (In review) Global potential net primary production predicted from vegetation class, precipitation, and temperature: comment. *Ecology.*

4. Determine variability in spatial predictions of NPP derived from existing algorithms and remote methods applied to the region [Objective (e)]

Tropical forests capture around forty percent of global terrestrial carbon in the form of standing timber, foliage, reproductive components and roots (Chave *et al.* 2001; Lewis *et al.* 2004). In 2007 the International Panel on Climate Change (IPCC) identified global warming as the biggest threat to tropical forests worldwide due to their heavy reliance on constant temperature and rainfall for optimal performance (IPCC 2007). There is emerging evidence that these ecosystems, especially the warm lowlands, are already experiencing climatic conditions that are close to the growth optimum and that increasingly warm, dry conditions forecast under climate change may dampen productivity.

We applied three prominent models of net primary productivity (NPP) sourced from the literature to explore probable scenarios for rainforest productivity in the region. These models solve NPP as a limiting function of either annual precipitation or mean annual temperature. We demonstrate that existing models vary greatly in their estimates of productivity for current climate and future projected climate change scenarios. The Lieth model showed a slight increase in NPP for all emission scenarios for 2050, but stable or decreasing productivity for 2080 according to each emission scenario. The Schuur model was the only algorithm showing a direct positive relationship between increased productivity and future emission scenarios. Under current climatic conditions, the mean annual NPP was estimated to be 9.58 Mg C ha^{-1} yr^{-1}, but increased to 10.08 Mg C ha^{-1} yr^{-1} in a low emission scenario and 10.6 Mg C ha^{-1} yr^{-1} at a high emission scenario. Finally, the Del Grosso model predicted almost no change in NPP over time, regardless of emission scenario. Additionally, the spatial pattern of NPP differed considerably between models and there was poor agreement between models regarding the NPP value at a particular location and the environmental variable that is limiting it.

We suggest three strategies to improve predictions by clarifying uncertainty in models. This includes: (1) collection of additional empirical data on tropical forest NPP particularly from data poor high rainfall areas; (2) coupling empirical NPP data with concurrent and local microclimate data (rather than coarse long-term averages); and (3) inclusion of additional ecologically relevant variables such as soil and climate seasonality that are expected to influence NPP. The later is especially important given that climate change projections suggest a decline in rainfall values for tropical areas, with harsher and longer dry seasons. All three of these shortcomings are currently being addressed by data generated in this MTSRF project.

Valdex-Ramirez, V., Shoo, L., VanDerWal, J. and Williams, S. E. (In prep) Uncertainty of tropical forest net primary productivity under future climate change. To be submitted to *Global Change Biology*.

5. Exploration of possible map generation of cloud frequency for the region using MODIS satellite data in order to quantify the buffering of temperature due to the cloud layer [Objective (d)]

We have successfully trialled an approach to estimate cloud indirectly using estimates of solar radiation. This has been achieved by contrasting estimates of clear-sky solar radiation derived from first principles with estimates of solar radiation reaching the earth's surface measured from satellites. The difference between these estimates is expected to largely driven by attenuation of solar radiation due to cloud. Each method for estimating radiation is described in turn.

Solar radiation under clear sky conditions was estimated across the region for the middle day of each month using an 80 m resolution DEM. Calculations were implemented in GRASS GIS as the command *r.sun* (Neteler and Mitasova 2004). Solar irradiation was derived from the sum of all three components of global radiation (beam, diffuse and reflected) calculated at half hourly time steps. We included in the model twelve-monthly values of Linke turbidity (2000-2006) updated from Remund (2003) using recent MODIS and MISR satellite and AERONET ground data, courtesy of J. Remund (unpublished data). The command *r.sun* specifically included the shadowing effect of topography which has the potential to ameliorate exposure to solar radiation in mountainous regions.

Daily estimates of solar radiation reaching the earth's surface were summarised from data obtained from the Bureau of Meteorology (http://www.bom.gov.au/sat/solradinfo.shtml). Data are derived from energy budget calculations made using hourly visible radiation (Weymouth and Le Marshall 2001) information from Geostationary Meteorological Satellites (e.g. MTSAT-1R, GMS-5). Independent measurements from ground instruments have been employed by the Bureau of Meteorology to test and calibrate the algorithm used in the computer model.

The output of this project to map patterns of cloud formation is already being integrated into analyses to generate "regional maps describing thermal buffering due to complex topography" (see above).

6. Analyse available microclimate data from high elevation boulder fields on Thornton Peak. Quantify buffering effect of boulder microhabitats (containing high species endemism) by relating to ambient temperature traces and macroclimate inferred from Esoclim interpolations [Objective (c)]

One possible way species may circumvent or minimise impacts resulting from climate change is to utilize microhabitats that buffer against extreme climatic events (e.g. peak daily or monthly temperatures). We aimed to investigate the potential for micro-scale habitat characteristics to buffer a mountaintop endemic nursery-frog from exposure to heat stress in the summer and moisture stress in the dry season. The Beautiful Nursery-frog (*Cophixalus concinnus*) is predicted to be the first vertebrate species to go extinct in Australia's diverse tropical rainforests as a result of contemporary climate change. Boulder fields are a prominent feature of the landscape occupied by this geographically restricted species.

Data were obtained from weather sensors maintained for a period of twelve months in both an exposed and forested boulder field. Ambient summer temperatures above exposed and forested boulder fields were found to reach 34°C and 24°C respectively. However, temperatures were much cooler and more stable within the boulder fields themselves. For example, at a depth of just 1.8 m, summer temperatures varied as little as seven degrees (16-23°C) in exposed and four degrees (16-20°C) in forested boulder fields. Relative humidity was typically high throughout the year (>80%) within forested boulder fields. In the critical dry season period, relative humidity did not fall below sixty percent and quickly returned to more saturated conditions. We also provide evidence of regular and persistent surface wetting due to non-precipitation inputs of water (e.g. mist and condensation).

Combined, these results demonstrate that boulder fields provide heterogeneous environments capable of ameliorating exposure to stressful climatic conditions. Physiological and behavioural data are now needed to determine weather *C. concinnus* is already living close to its thermal limits and whether individuals are able to take advantage of the buffering potential of boulder fields by actively shuttling between microhabitats in direct response to changing, unfavourable environmental conditions.

A broader description of results will be presented at the forthcoming 2009 MTSRF Annual Conference: Shoo, L.P., Storlie, C. and Williams, S. E. (2009) *Potential for mountaintop boulder fields to buffer resident species against extreme climatic events*.

7. (a) Further findings and summary data from field surveys conducted on fauna and plants and from microclimate data collected and spatial refugia identified.

The collection of field data is progressing well and a group of staff and students are currently carrying out surveys across the entire altitudinal range for all sites across the

Wet Tropics. These surveys will continue in April and will be redone again during the dry season in June and September.

Monthly trips continue for the collection of microclimate data from permanent Hobo dataloggers and hydro buttons. These continue to be complied into the data base for microclimate and refugia data.

7. (b) Report to update progress towards assessment of extinction risk and ecological plasticity of vertebrate species and general progress associated with Objectives (a)-(g) above.

This project concluded at the end of 2008. The project objectives were met and the research associated with the project successfully identified a number of species and traits which make vertebrate species in the Wet Tropics more vulnerable to extinction risk associated with rapid environmental changes.

Project Milestones

- Completion of a database of life history and ecological traits for 240 Wet Tropics vertebrates, including birds, mammals, reptiles and frogs. This database, along with a variety of other information, is expected to be published in the journal *Ecology* as a metadata paper.
- Completion of a full composite phylogeny for 240 Wet Tropics vertebrates which allows ecological analyses to be carried out which can take into account the shared ancestral relationships between related species (through the use of independent contrasts, and other phylogenetic analyses). The phylogeny and associated files will be published with other data in the metadata paper (see above).
- A published review of the implications of climate change for life history and extinction risk in mammals (*Endangered Species Research*).
- Development of a model of extinction risk based on resistance and resilience - the ability of a species to both withstand an environmental perturbation (such as a cyclone or extreme temperature event) and it's ability to recover, or bounce back, following such an event. This model has been published, using data on 162 Wet Tropics Vertebrates, in the journal *Diversity and Distributions*.
- The extinction model (above) found that, in general, the frogs of the Wet Tropics are likely to be most at risk of extinction from climate change. In particular, many endemic frogs seem to have a very low capacity to recover from an environmental impact. The model identified the frogs *Taudactylus acutirostris* and *T. rheophilus* as most vulnerable - both these frogs are thought to be extinct, thereby confirming the robustness of the analysis. The results also highlight a number of species which appear to be at high risk of extinction, but are currently classified as Low Risk by the IUCN – we call for the conservation status of these species to be reviewed.
- Further analysis of life history traits and ecological plasticity focussed on comparing endemic Wet Tropics vertebrates with widespread species. We found that endemic species tend of display traits which will increase their vulnerability to extinction from climate change, including smaller geographic range (within the Wet Tropics), low reproductive output and high habitat specialization. The results are currently in revision for the journal *Global Ecology and Biogeography*.

Summary of communication activities undertaken to date, including minutes of meetings/workshops if applicable

Journal articles (published or accepted)

VanDerWal, J., Shoo, L.P., Johnson, C.N. and Williams, S.E. Abundance and the environmental niche: environmental suitability estimated from niche models predicts the upper limit of abundance. *American Naturalist*, accepted 21 January 2009.

VanDerWal, J., Shoo, L.P., Graham, C. and Williams, S.E. (2009). 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., Williams, S. and Shoo, L.P. (2009). New approaches to understanding late Quaternary climate fluctuations and refugial dynamics in Australian wet tropical rain forests. *Journal of Biogeography* 36, 291-301.

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, 280-288.

Johnson, C.N. and Isaac, J.L. (2009) Body mass and extinction risk in Australian marsupials: the 'critical weight range' revisited. *Austral Ecology*, 34, 35-40.

Williams, S.E., Shoo, L.P. (equal contribution), Isaac, J.L., Hoffmann, A.A. and Langham, G. (2008) Towards an integrated framework for assessing the vulnerability of species to climate change. *PLoS Biology* 6(12), e325.

Shoo, L.P. and VanDerWal, J. (2008). No simple relationship between aboveground tree growth and fine-litter production in tropical forests. *Journal of Tropical Ecology* 24, 347-350.

Journal articles (in review)

Shoo, L.P., Anderson, A. and Williams, S.E. On the status of the isolated Lewin's Honeyeater population (*Meliphaga lewinii amphochlora*) from the McIlwraith Range uplands, Cape York Peninsula. *EMU-Austral Ornithology*, in review.

Williams, S.E., Shoo, L.P., Henriod, R. and Pearson, R.G. Elevational gradients in assemblage structure and productivity of rainforest birds in the Australian Wet Tropics bioregion. *Austral Ecology*, in review.

Shoo, L.P. and Valdez Ramirez, V. Global potential net primary production predicted from vegetation class, precipitation, and temperature: comment. *Ecology*, in review.

Valdez-Ramirez, V., VanDerWal, J., Shoo, L.P. and Williams, S.E. Uncertainty of tropical forest net primary productivity under future climate change. *Global Change Biology*, in review.

Isaac, J.L. and Goodman, B.A. Life history allometries in tropical and temperate mammals: are tropical species really slow? *Global Ecology and Biogeography*, in review.

Isaac, J.L., Williams, Y.M., Williams, S.E., VanDerWal, J. and Johnson, C.N. Life history, ecology and extinction risk in rainforest vertebrates: are endemic species more risk prone? *Global Ecology and Biogeography*, in review.

Journal papers in preparation

Williams, S.E., VanDerWal, J., Isaac, J. and Shoo, L.P. Distributional and life history characteristics of the rainforest vertebrates in the Australia Wet Tropics. *Ecology* (Data Paper), in prep.

Williams, S.E., Williams, Y.M., VanDerWal, J., Isaac, J.L., Shoo, L.P. and Johnson, C.N. Niche breadth, rarity and extinction risk in a biodiversity hotspot. *PNAS*, in prep.

Shoo, L.P., Storlie, C., VanDerWal, J., Valdez Ramirez, V. and Williams, S.E. Topographic buffering: in search of cool refugia in a warming world. *Biotropica*, in prep.

Conference presentations (speaker in bold)

Williams, S.E. Public talk and seminar at Evolution 2009, Melbourne and, seminar at the Sackler Colloquium National Academy of Science (USA) on climate change and niches (December 2008).

Isaac, J.L., Williams, Y.M, Williams, S.E., Vanderwal, J. and Johnson, C.N. Life history, ecology and extinction risk: are endemic different? Evolution 2009, Melbourne.

Acknowledgements

Special thanks to the staff and management of the Daintree Discovery Centre for their time and providing a host venue for the workshop. This workshop was funded by ARC-NESS, Wet Tropic Management Authority and Reef and Rainforest Research Centre.

References

Williams SE, Shoo LP, Isaac JL, Hoffmann AA and Langham G (2008) Towards an integrated framework for assessing the vulnerability of species to climate change. *PLoS Biol* 6(12): e325.

Project problems and opportunities

A permit was granted by National Parks for a single field trip to the summit of Thornton Peak to conduct priority research associate with this project. Three people were involved for one week in January 2009 and conducted count surveys and physiological trials on two endemic microhylid frog species (*Cophixalus concinnus* and *C. aenigma*) considered to be highly vulnerable to climate change.

Communications, major activities or events

During milestone reporting period

See above section – Summary of any communication activities undertaken to date, including minutes of meetings/workshops if applicable.

Steve Williams participated in a workshop on extinction in Panama at the Smithsonian Tropical Forest Institute (August 2008).

Steve Williams, Yvette Williams, Jeremy VanDerWal, Luke Shoo and Joanne Isaac organised and participated in a workshop “Predicting climate change impacts on biodiversity: the way forward” workshop in the Daintree – funded jointly by ARC-NESS, WTMA and the RRRC, December 2008. Report provided below at Attachment 1 to this report.

During next milestone reporting period

Jeremy VanDerWal has been invited to participate in a workshop on downscaling global climate models at CSIRO Melbourne (February 2009).

Steve Williams, Jeremy VanDerWal, Luke Shoo, and Vanessa Valdez-Ramirez will attend the upcoming 2009 MTSRF Annual Conference to present results from their MTSRF funded research within the Centre for Tropical Biology and Climate Change, James Cook University.

Steve Williams will present a talk to the Threatened Species Group at DEWHA in Canberra in mid March.

Attachment 1 – Workshop Outcomes

‘Predicting climate change impacts on biodiversity: the way forward’

Convened by Associate Professor Steve Williams and Dr Yvette Williams

The purpose of the workshop was to bring together leading researchers in the field to develop a unified quantitative model to assess vulnerability of species to climate change. The workshop was held at the Daintree Discovery Centre, north Queensland from 17-21 November 2008 including three complete working days as well as adjunct meetings. The workshop was attended by a broad spectrum of researchers from three international and seven national institutions as well as representatives from a regional management agency (i.e. Wet Tropics Management Authority) and research body (i.e. Reef and Rainforest Research Centre) (see Table 1 for a list of participants). The workshop was funded jointly by ARC-NESS, Wet Tropics Management Authority (WTMA), and the Reef and Rainforest Research Centre (RRRC).

The impetus for the workshop stemmed from a recent publication in *PLoS Biology* that proposed a theoretical framework for integrating the activities of disparate disciplines involved in climate change impact research. The paper concluded that “the next great challenge will be to apply the theoretical structure of the framework to derive quantitative estimates of vulnerability across a broad range of taxa.” The activities of the workshop were a direct effort to meet this challenge and significant progress was made in this regard.

The first day of workshop was dedicated to a series of short background briefings. The first of these was given by Steve Williams and described the above theoretical framework and reemphasised the primary goal of the workshop. This was followed by presentations on recent advances in vulnerability research (eg. biophysical models of the fundamental niche) as well as specific issues or known impediments towards developing a model of vulnerability. Examples of the later include major factors such as evolutionary potential and micro-habitat buffering that contribute to vulnerability but have so far been poorly incorporated into assessments. The day concluded with an open discussion of presentations and potential solutions to some of the problems raised.

On the second day, participants were divided up among several small working groups. The first of these were concerned with the subjects of evolutionary potential, ecological adaptation and acclimation and biotic interactions and were challenged with the task of identifying parameters that are most important in governing vulnerability and to determine how parameters could be realistically characterised across a range of organisms. A forth working group was assigned the task of quantitatively linking inputs into a single unified model (e.g. bioclimatic habitat suitability models, biophysical models of the fundamental niche, demographic models, models of landscape dynamics, and models of evolutionary potential). Each working group summarised their findings and reported back to gathered participants before closing the day's activities.

The third day was given over to a general discussion of what still needed to be done to realise the goals of the workshop. This included a discussion of how workshop outputs should be communicated and who would be responsible for coordinating these activities. It was envisaged that publications would be generated across the working groups as well as several synthesis papers that deal specifically with the unified model and its testing using real data.

A major outcome of the workshop was the establishment of a single unified analytical model of vulnerability that incorporates all major factors contributing to vulnerability. That is, a practical strategy was conceived to integrate new and existing algorithms that describe vulnerability. Critical parameters were also identified along with strategies to collect necessary data to assign sensible values (observed or inferred) to the input parameters. As such, the most important, immediate output is expected to be an essay to Conservation Biology titled "Novel approaches for novel climates" that identifies the current shortcomings in vulnerability research and proposes the unified quantitative model that emerged from the workshop. This will be followed by a more comprehensive publication that reports on trials of the model. Trials will be comprised of case studies on well known candidate species and supplemented with sensitivity analyses to determine 'how much information is enough' if we want to be able to make meaningful predictions of vulnerability.

Other indirect benefits were also realised during the course of the workshop. There were extensive discussions on potential collaborative funding opportunities (e.g. upcoming NCCARF research grants, ARC Discovery grants) and exchange of ideas pertaining to new and existing research projects.

Table 1: List of participants involved in the Daintree workshop.

	Person	**Institution**
International		
1	Craig Moritz	University of California
2	William (Bill) Laurance	STRI Panama
3	Raymond Huey	University of Washington
Melbourne		
4	Ary Hoffman	University of Melbourne
5	Jane Elith	University of Melbourne
6	Brendan Wintle	University of Melbourne
7	Michael Kearney	University of Melbourne
8	Nigel Stork	University of Melbourne
Canberra		
9	Simon Ferrier	CSIRO
Sydney		
10	David Keith	NSW Department of Environment and Climate Change
11	Peter Wilson	Macquarie University
Brisbane		

12	Roger Kitching	Griffith University
Adelaide		
13	Barry Brook	University of Adelaide
Townsville		
14	Steve Williams	James Cook University
15	Jeremy VanDerWal	James Cook University
16	Joanne Isaac	James Cook University
17	Jo Holtum	James Cook University
18	Richard Pearson	James Cook University
19	Luke Shoo	James Cook University
20	Yvette Williams	James Cook University
Cairns		
21	Andrew Krockenberger	James Cook University
22	Steve Goosem	Wet Tropics Management Authority
23	Ellen Weber	Wet Tropics Management Authority
24	Mellissa Jess	Reef and Rainforest Research Centre