Australian Government

Department of the Environment, Water, Heritage and the Arts

Marine and Tropical Sciences Research Facility Milestone Report, November 2007

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 is currently on track for meeting all milestones. The planned meeting for the integrated physiology and field studies of refugial dynamics and ecological plasticity has occurred and extensive planning of this integrated project has taken place (see following report).

The continued monitoring of field sites has occurred with no current problems. The assessment of extinction risk and vertebrate vulnerability is progressing well and the results have already been taken up in national and international workshops on climate change impacts. A manuscript reporting this work is now complete and has been submitted to *Conservation Biology.* This project will now look at more complex ways of analysing this data. Both the spatial refugia project and the complication of microclimate data is ongoing and both are progressing well.

Included below is a report detailing the progress on the species distribution modelling. Distribution models for all rainforest vertebrates have been completed using one of the most up-to-date modelling algorithms (MAXENT). These distribution maps have been very valuable for providing more accurate and informative models of species distribution for both realised and potential distribution and the climatic variables which are driving these outputs. We are in the process of publishing these maps (attached, following) and discussing with the Wet Tropics Management Authority on the best way to provide the maps to the public via their website as downloadable maps.

The next milestones report (February 2008) will see verbal progress update to the Rainforests and Catchments Operations Committee on:

- Progress on projections of climate change impacts on species distribution using IPCC predictions.
- Progress and status update on the assessment of extinction risk of vertebrate species, identification of regional-scale refugia, field surveys and status report associated with objectives (a)-(g) (above)
- Summary of any communication activities undertaken to date, including minutes of meetings/ workshops if applicable.

Project Outputs / Milestones

Report 1 Milestones:	Due Date
1. Participation in a MTSRF-wide meeting (to be organised by the RRRC but funded from the project communication monies) regarding climate change modelling, scenario development and mapping of deliverables across the MTSRF.	8 November 2007
2. Plan of communication activities / products for Year 2 and comments regarding how outputs from the MTSRF-wide meeting influences this project.	8 November 2007
3. Report on meeting between Steve Williams, Luke Shoo (MTSRF-funded postdoctoral fellow) and Andrew Krockenberger to describe outputs from meeting regarding integration of physiology and field studies of refugial dynamics and ecological plasticity.	8 November 2007
4. Preliminary data form field surveys conducted on fauna and plants associated with Objectives (a)-(f) (above) – progress update on the assessment of extinction risk and ecological plasticity of vertebrate species, identification of spatial refugia, compilation of microclimate data from data loggers at all sites.	8 November 2007
5. Draft report of species distribution models using MAXENT including all relevant maps.	8 November 2007

Project Results

Milestone 1: Meeting to discuss predictive scenarios for modelling climate change and its impacts

This meeting was to be organised by the RRRC but it has not been held to date. This is of little consequence. The researchers involved in terrestrial climate change work (David Hilbert, Suppiah Ramasamy, Steve Williams and Jeremy VanDerWal) did meet and discussed the various scenarios for modelling. Suppiah has provided the report on the latest climate modelling at ten-year intervals through to 2090 and it is these scenarios that we are using in all climate change predictions. I am not convinced that this meeting, as it was originally suggested, is still necessary.

Milestone 2: Plan of communication activities / products for Year 2 and comments as to how outputs from the MTSRF-wide meeting influence this project

Proposed communication product / event	Date
Meeting (October) with WTMA staff: Discussed potential ways that we could place all the species distribution maps onto a public access server on the WTMA site. This will mean up-to-date distribution maps of all rainforest vertebrates will be accessible to anyone wishing to download them.	2008
Discussing the idea of a workshop at WTMA to present ongoing research on climate change and to obtain management feedback.	Early 2008

Proposed communication product / event	Date
Fire workshop being organised by WTMA. Include our participation (Steve Williams and Jeremy Little).	Not sure
Ecological Atlas of vertebrates of the Wet Tropics: a major book that includes distributions, abundance patterns, habitat preferences, environmental preferences and natural history (photo, map, graphs and text on all rainforest vertebrates) To be published during 2008 provided fund for publication can be found.	Late 2008
Scientific communication – various presentations have been undertaken and are planned including Plenary talk at the Australasian Ornithological Congress; Ecological Society of Australia; workshops on assessing the vulnerability of biodiversity in Australia (Australian Greenhouse Office), SPECIES, CLIMATE CHANGE AND EXTINCTION (IUCN, London, October 2007); Greenhouse 2007.	ongoing

Milestone 3: Report on meeting between Steve Williams, Luke Shoo (MTSRF-funded postdoctoral fellow) and Andrew Krockenberger to describe outputs from meeting regarding integration of physiology and field studies of refugial dynamics and ecological plasticity

Microhylid Physiology Project Meeting
James Cook University, Cairns, 7 September 2007

In attendance: Steve Williams, Andrew Krockenberger, Luke Shoo, Johan Larson, Andres MerinoViteri.

Goal of physiology project:
To undertake meaningful measurements of real physiological limits and tolerances of microhylid frogs. Ideally, to go beyond simple comparison of relative tolerances among species and measure the actual real tolerance of species and relate these directly to real conditions experienced in the field. This information could then be used in conjunction with broad climate layers to scale up climatic requirements and produce mechanistic based distribution models and predictions of climate change impacts. Preferably methods would be carried out in the field without causing mortality to target species.

Broad scope of project:
<u>First pass:</u> Collect basic physiological information on all species from at least one location and microclimate data across climatic gradient to establish exposure and conditions under which species occur and are absent. <u>Second pass</u>: Compare physiology of populations on the margin of the climatic envelope to core populations. <u>Third pass</u>: Compare physiology of different genetic lineages within species.

A main priority of the meeting was to determine what equipment would be needed in order to quantify physiology of microhylid frogs. **The decision was made to purchase a plant photosynthesis system (LI-COR 6400) and construct water-bath and temperature gradient apparatus.**

1. Quantifying respiration and water loss under controlled temperature and humidity

Two options put forward by Andrew: (a) standard animal respirometer; or (b) plant photosynthesis system – LI-COR 6400. The relative benefits of both systems were discussed but the plant photosynthesis system was considered most appropriate for the purpose of the project. A summary of this system is provided below.

1.1 Plant photosynthesis system – LI-COR 6400

(http://www.licor.com/env/Products/li6400/6400.jsp?h=qfep6400)

Air pumped into small chamber housing frog, temperature and humidity are set and change in CO_2 measured. Not previously used for this purpose but has a number of good features.

Positives: Good control of temperature and humidity. Very sensitive sensors (infared gas sensor) suitable for measuring small change in CO_2. Portable and operable in the field, runs on car battery, built in microcomputer with serial cable or memory stick for data transfer, apparatus estimated to be about ten kilograms including heating system. Single car battery expected to run apparatus for several hours. Peter Franks uses one battery per day when using same machine on the canopy crane. Change in CO_2 can be used to infer metabolism. Metabolism has been previously used in mechanistic climate change models by Kearney and Porter (2004 Ecology 85, 3119-3131) and Kearney (2006 Oikos 115, 186-191). These models are very parameter intensive but data from LI-COR 6400 will go someway towards filling in data for missing parameters.

Negatives: More expensive system than standard animal respirometer (45 k versus 20-25k). Limited range over which temperature and humidity can be manipulated. For temperature this means about $\pm$ 10°C relative to ambient. High humidity is problematic as leads to condensation on sensor. Not a problem with plant experiments that are usually run under dry conditions. Steve points out that microhylids are usually found in high humidity but that replicating this is not a priority as we are interested in measuring response to limiting conditions (i.e. not preferred humidity). Apparatus is not suitable for operating in rainy conditions. Only measures CO_2 and not oxygen consumption but field metabolic rates are routinely calculated from CO_2. Need to know something about the substrate (food source) the animal is using to infer metabolism from CO_2 though.

Pilot testing: Johan and Andrew have trialed LI-COR 6400 on small 1 gram *Bufo marinus.* Data from trial was not considered satisfactory but it was clear that the problem was due to the fact that *Bufo* jumped around and would not stay still in chamber when measurements were being taken. If animal is active CO_2 consumption goes up. Because sensors provide and integrated estimate over time (ie. are not instantaneous) this caused problems with data. It is thought that this will be less of a problem when running trials on frogs that are likely to settle into a still, water conservation posture when subject to the same conditions.

Considerations: It was suggested by Andrew that it would be desirable to continuously measure weight loss over time when frog is in chamber (i.e. not just a start and finish weight). This could be achieved by drilling a small hole in the bottom of chamber and inserting a weighing scale.

Andrew suggested that it would be useful to estimate the likely metabolic rate in the dry season when animal is inactive to see if metabolic demands are limiting. However, we do not have any direct evidence to say that animals are inactive for a part of the year. Weak growth bands in skeletochronology suggests not. Yvette Williams has examined stomach contents in these species but collection dates are predominantly from the wet season so limited data available to infer feeding in dry season. Also, priority species are from cool environments that are expected to have relatively lower metabolic demands.

Substrate needs to be determined to perform metabolic calculations but Andrew suggests that it should be sufficient to just use diet and allometric equations for prey from literature. Need to talk further about the benefits of holding animals for 24 hours prior to experiment to purge stomach contents and available substrate for metabolism. Well fed animals will utilize carbohydrates while fasted animals will use fats.

Andrew estimates processing time in the field to be about 1 hour per individual at one temperature and humidity. It takes about 5-10 minutes to washout and stabilise conditions in chamber. We would then aim to have the animal exposed to treatment for about half an hour. A *Bufo* was trialed for about an hour and had already lost about 20% of body weight but air flow at some stages was very high. It was estimated that two people working in the field should be able to perform about ten trails in a day. Level of replication (no. of trials) will depend on variability in data. It was suggested that a common species such as *Cophixalus ornatus* be trialed for a range of temperatures (10-30°C) at five-degree increments and at a range of humidity (20-80%) at ten-percent increments. Need to discuss further protocol for keeping animals for 24 hours to purge stomach contents and scope for repeated trails of the same individuals.

It will be necessary to use a cover shield to prevent air movement over balance during trials.
Yet to be seen whether we can recreate the full climate envelope with machine based experiments in the field. As a bare minimum, it is proposed to run experiments at moderate humidity (i.e. 50-60% as we want to avoid going above about 80%) and measure water loss at a range of temperatures. Tolerance may be higher than what we can actually measure but won't know until we try. Preferred approach would be to then go to the literature to determine lethal water loss and use trends in water loss to infer time to mortality. Time to critical cumulative water loss or respiration rate could be inferred by extrapolating trends from experimental data to critical physiological thresholds gleaned from literature (i.e. other rainforest frogs of similar size). Ten percent water loss in most mammals is lethal and about forty percent in desert frogs.

Potential exists to run trials of righting response time for animals immediately after being removed from chamber. This would allow critical tolerances for water loss to be assessed in addition to temperature (see below).

2. Quantifying temperature tolerances and limits

2.1 Water-bath experiments

A holding bowl is floated in a water-bath that is gradually heated or cooled to yield experimental temperature conditions. Animal is held in bowl and assessed for righting response (i.e. time taken for animal placed on back to return to a natural posture). Response time is expected to be quickest at optimum temperature and become increasing slow as animal is exposed to upper and thermal limits.

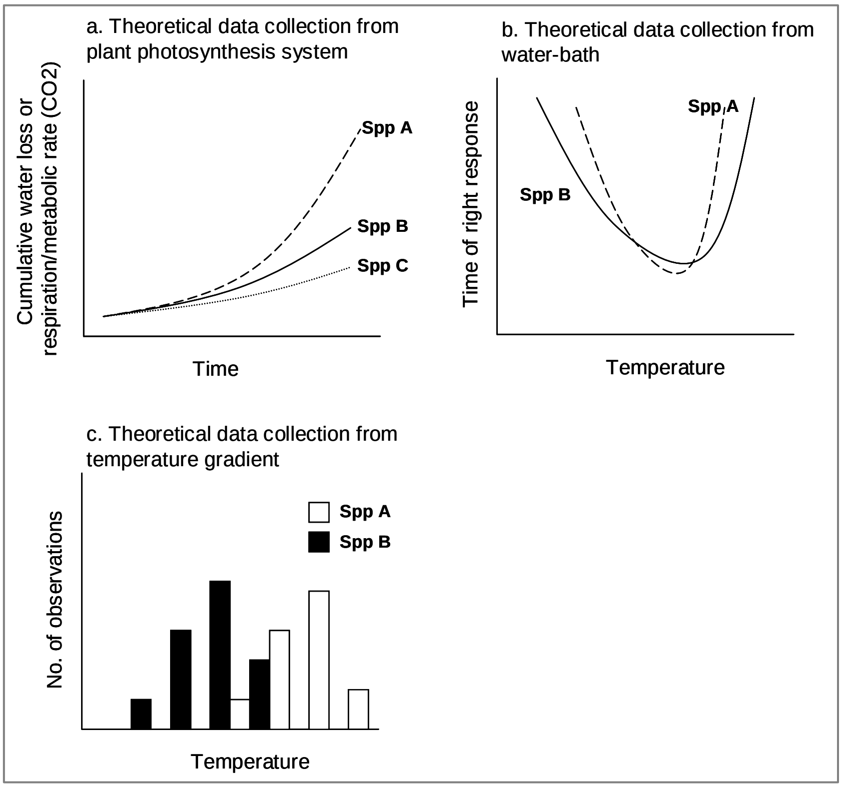
Considerations: Need to keep animals hydrated with small amount of water in holding bowl. Need to develop a protocol for assessing meaningful righting response in microhylid species. Water will need to be heated and stirred during trial. Suggested use of a 12 volt jug element and battery operated aquarium aerator. Need to measure temperature. Suggested use of thermocouple for this purpose.

2.2. Gradient experiment

Individuals are placed in a linear temperature gradient and allowed to select for optimum temperature.

Considerations: Need to keep animals hydrated. We need to achieve heating but without employing a light source. Suggested use different densities of coiled heating wire. Will need to determine a calibration period for the amount of time required for a frog to actively choose temperature and settle. Conduct in experiments in constant dark enclosure. It should be possible to use time lapse camera to make observations at regular intervals to build up a profile of frequency of use of points along temperature gradient. Steve suggests that it would be good if we could construct a platform with more than one gradient so that multiple individuals can be tested simultaneously (e.g. five parallel gradients). A camera could be mounted over the whole platform to record observations.

3. Theoretical data output from physiological experiments



4. General protocols for physiology experiments

Morphology of all experimental individuals should be measured. A toe clip should be taken for ongoing genetic work and for retrospective identification or lineage determination. When visiting field sites on multiple occasions check for evidence of toe clip and do no do use previously tested animals. Mark point of capture and return all individuals to their respective locations after field experiments have been conducted.

5. Potential value adding for equipment purchase

Only minor adaptations to the LI-COR 6400 apparatus would be required for later applications including determining the physiology and energy demands of geckos, skinks and larger frogs. [An additional application NOT YET DISCUSSED would be to purchase add-on components to measure soil respiration. The machine could then be employed at standard forest plots to measure soil respiration for input into calculations of net primary productivity.]

6. Anchoring physiology to real conditions experienced in the field

Measurement of climate in field refuges is important for two reasons. First it will ensure that realistic exposure levels are being used in physiological experiments. Second, it will provide a direct measure of what the critical conditions or periods might be in the field. It should be possible to build up a spatial and temporal picture of how conditions vary and identify conditions that are likely to actually limit distribution of species in the field. Climate conditions can be measured at a number of levels:

a. Regional climate surfaces (e.g. BIOCLIM, Esoclim);
b. Hobo weather stations already deployed in the field and currently logging air temperature, soil temperature, humidity and soil moisture at fifteen-minute intervals; and
c. Log microclimate in specific refuges. Some existing data already available on microclimate under fallen logs. Temperature traces from iButtons under logs accompanying Hobo weather station data also. Collin Storlie took derived soil moisture from oven dried soil samples taken under 400 logs. Scope to expand microclimate data in refuge areas along environmental gradients (component of Andres project)

<u>Considerations:</u> Microclimate and physiology data will be potentially decoupled in time. Should be able to characterise refuge conditions from microhabitats known to be utilised in the wet season when animals are easy to locate. Limiting physiological conditions though may well occur in the dry season when individuals are difficult to locate (Collin Storlie rolled 400 logs in June and found just fifteen microhylid frogs but there is potential to take advantage of Earthwatch volunteers to expand search effort for this purpose if needed). Andrew points out that the rolling of logs may disturb the refuge and alter microclimate. It was suggested that it may be better to insert thermocouples instead. There is also the added difficulty that we will be only able to characterise the climatic conditions for a particular year or season which may not reflect long term patterns.

7. Scaling up

a. Experimental assessment of physiological tolerances and limits;
b. Characteristation of microenvironment in refuge site (adults and eggs);
c. Local forest plot level climate data from HOBO weather station; and
d. Regional climate layers (BIOCLIM, Esoclim).

8. Tasks stemming from meeting

<u>Andres:</u>

- Check for the most recently available equipment for immediate measurement and logging of microclimate (eg. soil moisture) in refuges located in the field.
- Explore options to examine the physiology of eggs (incubation time/mortality versus temperature, humidity, soil moisture).
- Literature search for other studies using water-baths and gradients on frogs (suggest contacting Brett Goodman for some advice in this area). Start assembling both set ups in conjunction with Johan.

- Correspond with Andrew for ethics submission. Next ethics meeting in JCU Cairns is Tuesday 18 September 2007. Things to include in ethics submission: experiments conducted in situ, non lethal methods, animals will be returned to point of capture, small number of individuals used (10-20 from one place) therefore small impact, ethics previously granted for similar projects.
- Organise amendment to National Park permit to include physiological experiments.
- Calibrate had held (Fluke) infared temperature gun. Andrew suggests taking measurements of a black painted bowl floated in water of known temperature. Repeat at different water temperatures and construct a calibration curve.

<u>Johan:</u>

- Explore options for equipment for temporarily keeping animals in field.
- Check field fridge is working.
- Literature search for other studies using water-baths and gradients on frogs. Start assembling both set ups in conjunction with Andres.
- One third time in dry season and two thirds of time in wet season to be allocated to microhylid physiology project.

<u>Andrew:</u>

- Print quotes for LI-COR 6400 [and expanded temperature control kit 6400-88?] and correspond with Yvette Williams for purchase of machine and batteries with a goal to be operational by beginning of December.
- Adapt machine to incorporate scale balance into chamber.

<u>Steve, Andrew, Luke, Andres, Rohan:</u>

- Combined field trip to test experimental set up (Early December, January). Collect a small sample of *Cophixalus ornatus* from Kuranda-Tablelands and bring back to JCU lab to trail methods and ensure that apparatus are yielding sensible results.

Milestone 4: Preliminary data from field surveys conducted on fauna and plants associated with objectives (a)-(f) above. Progress update on (1) the assessment of extinction risk and ecological plasticity of vertebrate species; (2) identification of spatial refugia; and (3) compilation of microclimate data from data loggers at all sites.

1. Progress report on the links between extinction proneness and ecological characteristics of each species using collation of existing data and literature.

Following on from progress reported previously, we recently conducted an analysis to predict extinction risk in 163 Wet Tropics vertebrates, including 70 species endemic to the region. We used 17 traits, taken from our completed database of life history and ecological variables, and multivariate analyses to determine whether these traits can accurately predict current IUCN category of those species which are listed. Analysis determined that the best performing model, which explained the most variation in IUCN category (65%), contained only 9 of the 17 traits (Table 1). We then used discriminant function analysis to see how well these traits predicted IUCN category. The model containing all 17 traits successfully assigned the correct category to 87% of species, while the reduced model containing only those traits identified in the regression model performed better and correctly assigned 88% of species to the correct category.

Most importantly, using this method we were also able to assign a predicted IUCN category to 36 Wet Tropics species which are not currently assessed by the IUCN. This is most critical for reptiles, our research shows that 97% of reptiles in the Wet Tropics and Cape York are not currently assessed by the IUCN, and most are not assessed on national threat lists (Isaac *et al.* in review at *Conservation Biology*). Our results indicate that up to 10 of these species should be considered as being at high risk of extinction, as they were predicted to fall in the IUCN categories of Critical, Endangered or Vulnerable (Table 2). Many of these are restricted endemics; however the reduced model did not include geographic range size, indicating that factors other than a small range size contribute to the vulnerability of these species.

These results indicate that life history and ecological data can be used to predict an IUCN category for non-assessed species where data on population size and trends is lacking. This is important, as increasingly managers turn to conservation lists such as the IUCN Red List to inform them when setting conservation priorities and allocating resources. Our method allows the 36 species not currently assessed by the IUCN to now be considered equally with other species when conservation planning for the Wet Tropics region is carried out. A manuscript reporting this work is now complete and has been submitted to *Conservation Biology.*

2. Progress report on identification of spatial refugia – ecological plasticity of vertebrate species and identification of spatial refugia

We have initiated a review of literature pertaining to ecological plasticity of vertebrate species and the potential for spatial refugia to buffer against climate change. Montane boulder fields have been identified as a high priority microhabitat for investigating buffering potential within the Wet Tropics. This is because key vertebrate taxa that are predicted to be immediately threatened by climate warming, including the Beautiful Nursery-Frog (*Cophixalus concinnus*) and two lizard species (*Eulamprus frerei* and *Techmarscincus jigurru*), are almost entirely restricted to montane boulder fields.

Data from a pilot study of temperature loggers in boulder fields of Thornton Peak (January to December 2006) has been extracted and analysed. Microclimates within boulder fields were shown to be strongly buffered against extreme maximum temperatures. Maximum recorded temperature for the data collection year was 13.5°C cooler at a depth of five metres than at the surface of the boulder field (19.5°C and 33.0°C respectively). An 8.5°C of buffering from maximum temperatures was achieved at a mere 1.5 metres depth in the boulder field. Deeper positions in boulder field that were buffered against extreme temperatures also experienced much more stable ambient temperatures.

Data collection has been expanded to enable conditions in exposed boulder fields to be compared with boulder fields under forest canopy. A field trip to Thornton Peak is planned for late November 2007 to allow maintenance of data loggers and collection of the first months of replicated data from boulder fields. We are investigating methods that will allow us to concurrently quantify ecological plasticity of target species in response to fluctuating temperatures. Specifically we are interested in quantifying spatial movements of relevant taxa in boulder fields and the environmental conditions that accompany use of buffer microhabitats. It is envisaged that these methods will be trialled early 2008.

3. Progress report on compilation of microclimate data from data loggers at all sites.

Site Name	Decimal Latitude	Decimal Longitude	Elevation (meters)	Date Logger Deployed	Days Since Deployment
SU350A2	-19.01484047	146.2654037	350	01/11/2006	372
SU6A2	-19.00261633	146.2415251	600	01/11/2006	372
SU8A2	-19.01134381	146.2214001	800	01/11/2006	372
SU10A2	-19.01581198	146.1583569	1000	01/11/2006	372
SU10B2	-19.00378261	146.2092744	1000	01/11/2006	372
AU1A3	-17.71884301	145.8582907	100	11/11/2006	362
AU2A2	-17.66250574	145.8727964	200	12/11/2006	361
AU4A2	-17.61131255	145.7647749	400	13/11/2006	360
AU6A2	-17.67196195	145.7154257	600	01/03/2007	247
AU8A2	-17.60185257	145.6333563	800	12/11/2006	361
AU10A2	-17.7016746	145.5235387	1000	12/11/2006	361
BK10A2	-17.2659517	145.8698719	1000	01/05/2007	155
BK12A2	-17.26264035	145.8548889	1200	01/06/2007	125
BK14A2	-17.26438685	145.8584526	1400	01/05/2007	155
BK16A2	-17.26682387	146.0391982	1600	01/05/2007	155
CU1A1	-16.46941746	145.326124	100	11/12/2006	332
CU2A2	-16.47113826	145.3209582	200	11/12/2006	332
CU4A2	-16.53450908	145.3718164	400	08/12/2006	335
CU6A2	-16.57924751	145.3046464	600	09/12/2006	334
CU8A2	-16.58796523	145.2965859	800	09/12/2006	334
CU10A2	-16.55722655	145.2772461	1000	09/12/2006	334
CU12A2	-16.51423043	145.2695437	1200	09/12/2006	334
WU9A2	-16.28467419	145.0840324	900	15/11/2006	358
WU11A2	-16.25941972	145.0436055	1100	15/11/2006	358
WU13A2	-16.23553981	145.0088247	1300	15/11/2006	358

The CTBCC has been maintaining a climate monitoring program across a gradient of latitude and altitude within the Wet Tropics for over one year. The above table lists the locations at which HOBO loggers have been deployed and for how long they have been gathering data. Each logger consists of five sensors which measure air temperature, relative humidity, soil moisture, soil temperature, and condensation. To date the array of 25 data loggers has gathered 578,000 readings for each of these five variables.

Currently the CTBCC is performing monthly maintenance of all HOBO data logger setups to insure they are functioning correctly. This maintenance includes downloading the data from each logger, replacing any faulty sensors, and replacing low batteries. The data downloaded is then immediately backed up to our Master Environmental Database so that it can be used in analyses and stored safely. Also underway is the calibration of each soil moisture sensor independently. Monthly soil moisture samples are taken from the vicinity of each logger. These samples have their volumetric soil moisture determined by weighing the sample wet, drying the sample and then weighing them again. This value is compared to the volumetric soil moisture reading from the soil moisture sensor so that we may construct a calibration curve. This process will allow the accurate prediction of soil moisture across a variety of different soil types.

Milestone 5: Draft report of species distribution models using MAXENT including all relevant maps

Summary

Species distribution models were created for 196 rainforest vertebrates for the Wet Tropics in northeast Queensland. Species occurrences were records from the Centre for Tropical Biodiversity and Climate Change which has been collecting occurrence and abundance information from field studies and collated from other sources. Such records were then used as inputs into MAXENT, a species distribution modelling program based on maximum entropy algorithms to predict likelihood of locations being part of a species distribution. The distribution models produced represented the potential niche of a species and were subsequently clipped by expert opinion to represent the realized distributions based on biogeographic barriers. Presented here are images of the realised distributions (in appendices) and summary richness maps for each of the major taxonomic groups.

Background

As part of a number of ongoing projects (e.g. MTRSF programs), studies and research (e.g. research associated with the Centre for Tropical Biodiversity and Climate Change), conservation plans (e.g. Wet Tropics Management Authority planning), etc., there was a need to have general knowledge of where rainforest vertebrate species occurred within the Wet Tropics regions in northeast Queensland. For many species, occurrence records were tracked permitting estimation / modelling of the current distribution for the region. Thus, this interim report presents the methodology and distributions for 196 rainforest vertebrates found in the Australian Wet Tropics region.

Methods

The potential distributions for all 196 rainforest vertebrate species of interest here were created using Maxent (Phillips *et al.* 2006), species occurrence data and climatic, topographic and vegetation environmental data. Maxent utilises a maximum entropy algorithm to produce estimates of the potential distribution of a species (Phillips *et al.* 2006). This algorithm represents a novel approach to species distribution modeling that has been shown to outperform other algorithms or techniques traditionally used in this type of study (Elith *et al.* 2006, Hernandez *et al*. 2006) and was most capable of dealing with small sample sizes when compared with Bioclim, Domain and GARP (Hernandez *et al.* 2006). Suitability as part of the species potential distribution is estimated as a function of the environmental variables for each cell within a gridded domain (area of interest). Advantages of MAXENT include: the program uses presence only records; incorporates interaction effects of environmental variables; being a deterministic algorithm that always converges to a unique, optimal probability distribution (Phillips *et al.* 2006); and most recently, when projecting onto a different set of environmental variables (different location or time), areas that fall outside the current conditions are identified (clamped areas) (Steven Phillips, pers. comm.).

Distributional data was supplied by the Centre for Tropical Biodiversity and Climate Change (CTBCC). The distributional data represents data collected from intensive field surveys across the region (done by staff and students associated with the CTBCC) and by collating all available sources from literature and institutional databases (Williams 2006).

The climatic data included annual mean temperature, temperature seasonality, and maximum temperature of the warmest week, coldest temperature of the coldest week, annual precipitation, precipitation seasonality, precipitation of the driest quarter and precipitation of the wettest quarter. All of the climatic data were created using the Anuclim 5.1 software (McMahon *et al.* 1995). Aspect and slope, the topographic data, were derived from an 80m resolution DEM (resampled from GEODATA 9 Second DEM Version 2; Geoscience Australia, http://www.ga.gov.au/) and the vegetation data was floristically classified broad vegetation groups (BVG at a 1:2million resolution; Accad *et al.* 2006). The area under the curve of the receiver operating characteristic (AUC) was used to test the predictions, defining the discrimination ability (between presence and background) of the models (Mantel *et al.* 2001).

MAXENT produces spatial predictions of environmental suitability as a value between 0 (not suitable) to 100 (most suitable). The MAXENT prediction was clipped at a threshold that represents the minimum prediction value of all occurrences as to be conservative and minimize errors of omission. The predicted values between the threshold and 100 (maximum predicted MAXENT value) were then equally divided into five categories; greater numbers representing greater likelihood of optimal habitat conditions.

The potential distributions were then clipped to exclude biogeographic regions where the species is known not to occur; thus creating a series of realised distributions. The expertise of Stephen E. Williams[1], Yvette M. Williams[1], Luke P. Shoo[1], Conrad Hoskin and Craig Moritz[2] were used to clip the potential distributions to their associated realized distributions. These distributions were transformed into a binary map representing not part of the distribution vs. realised distribution for further analysis.

The binary predictions (category 0 vs. 1) were summed for all species, birds, frogs (excluding microhylids), mammals, microhylids and reptiles to produce species richness maps for the region. The richness maps produced represent the potential species richness of any location based on overlapping realized distributions. The taxonomic group to which a species belongs can be found in Appendix 1.

Results and Future Work

The potential and realised distributions have been created for each of the 196 rainforest vertebrates listed in Appendix 2. Images of realized distributions for all individual species are presented here in Appendix 2. These models are being projected onto future climate scenarios for examination of potential distribution shifts and/or losses.

Summary species richness maps have been created presented here as Figures 1 to 6. These are currently being examined in light of historical habitat stability and contemporary climate.

Final distribution maps and summary richness maps will to be presented to collaborators (including CSIRO and other MTSRF stakeholders) for use in the near future.

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[1] Affiliation: Centre for Tropical Biodiversity and Climate Change Research, School of Marine and Tropical Biology, James Cook University, Queensland, Australia
[2] Affiliation: Museum of Vertebrate Zoology, Berkeley, California, USA

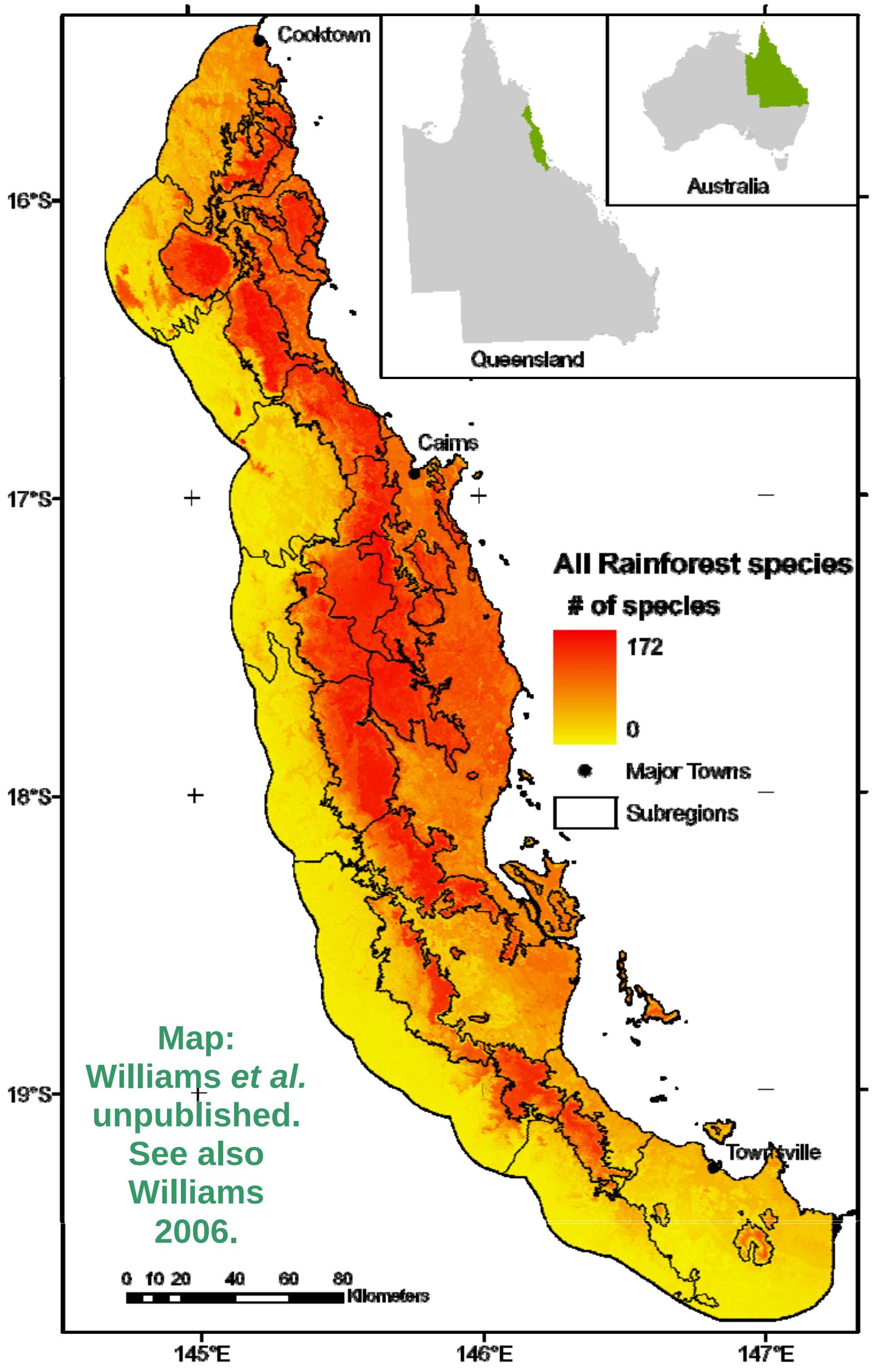

Figure 1: Rainforest vertebrate richness based on overlapping distributions for 196 vertebrate species found in the rainforests of the Australian Wet Tropics.

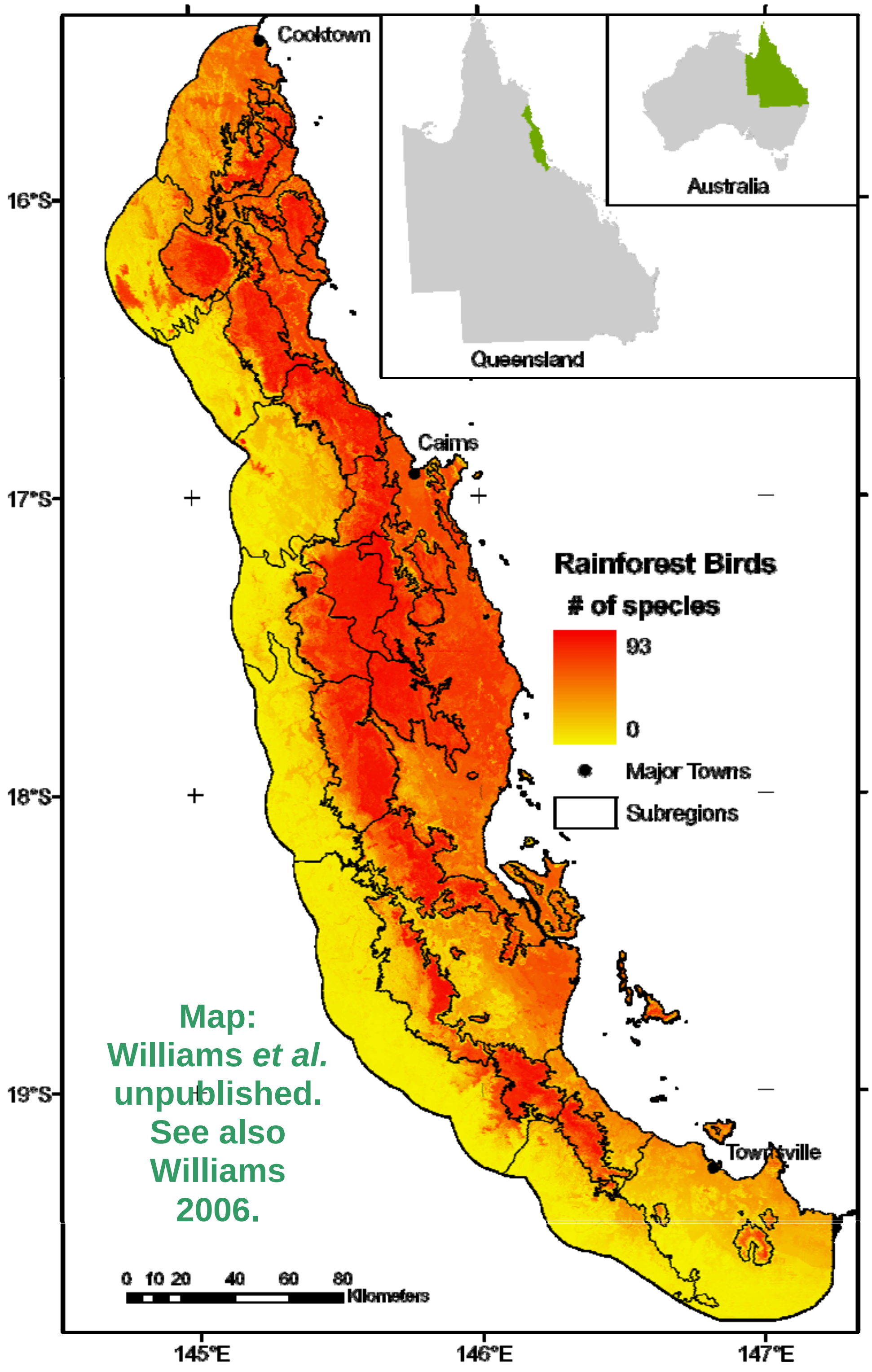

Figure 2: Rainforest bird richness based on overlapping distributions for bird species found in the rainforests of the Australian Wet Tropics.

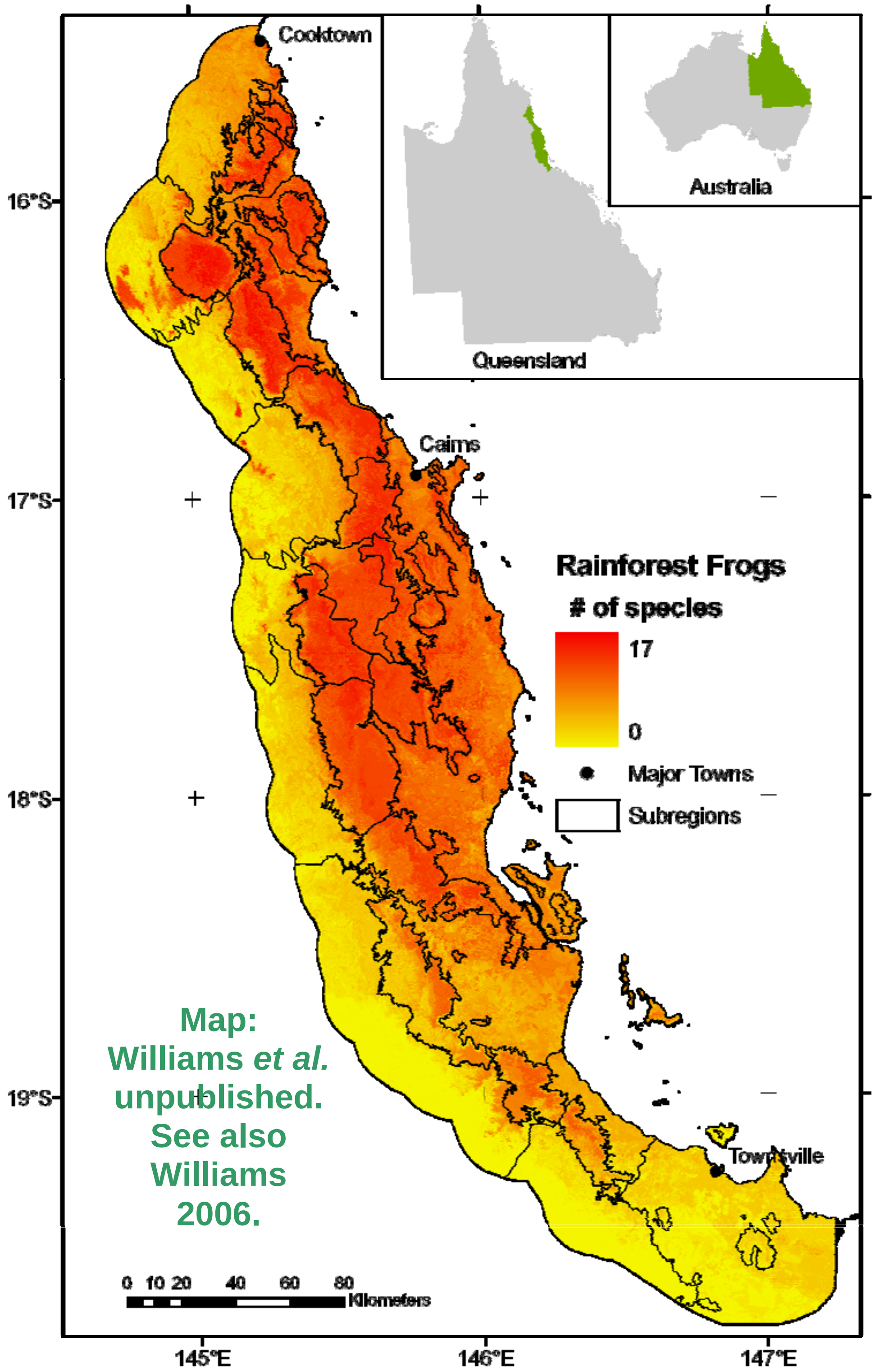

Figure 3: Rainforest frog richness based on overlapping distributions of frog species (excluding microhylids) found in the rainforests of the Australian Wet Tropics.

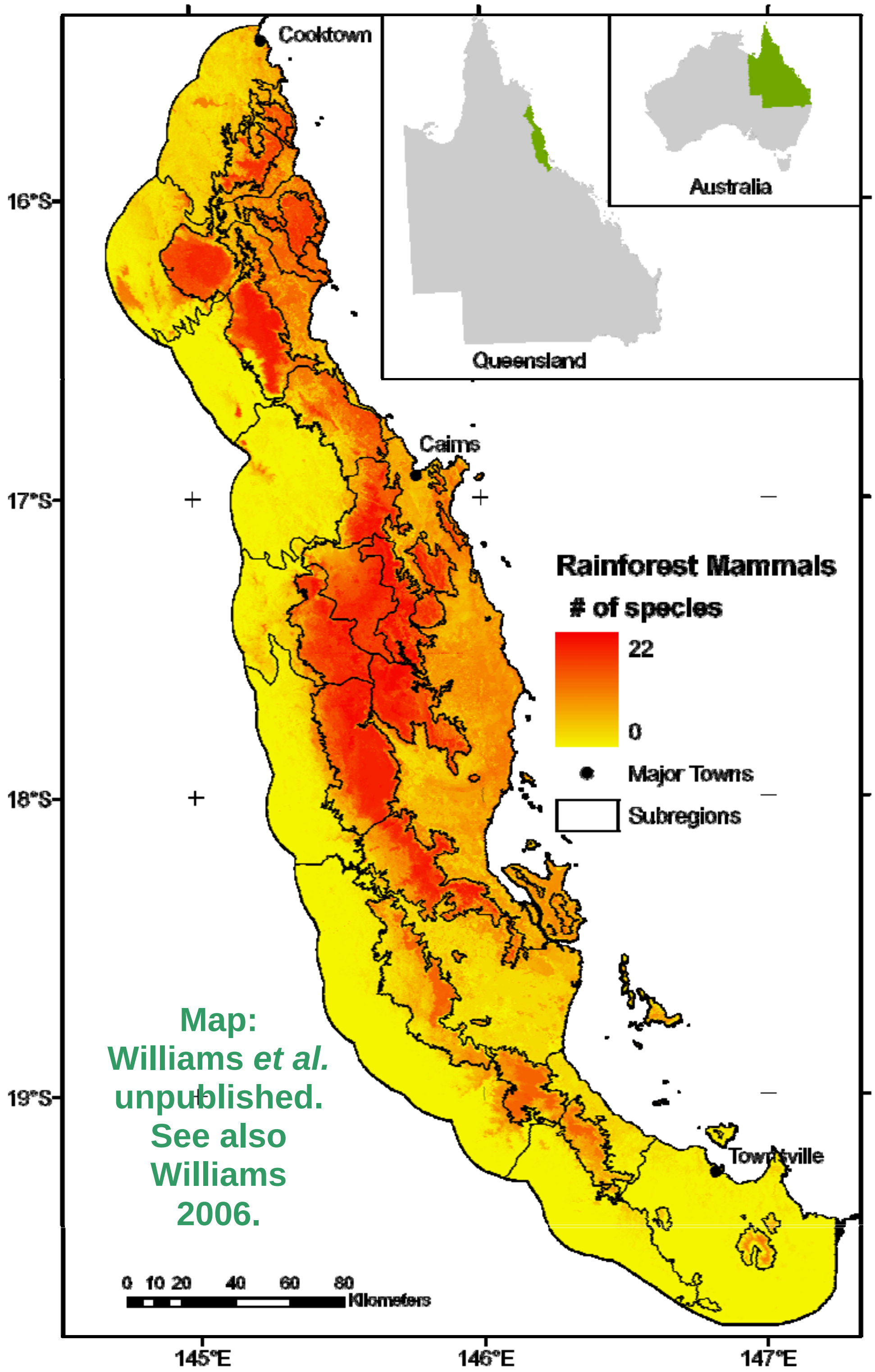

Figure 4: Rainforest mammal richness based on overlapping distributions for mammal species found in the rainforests of the Australian Wet Tropics.

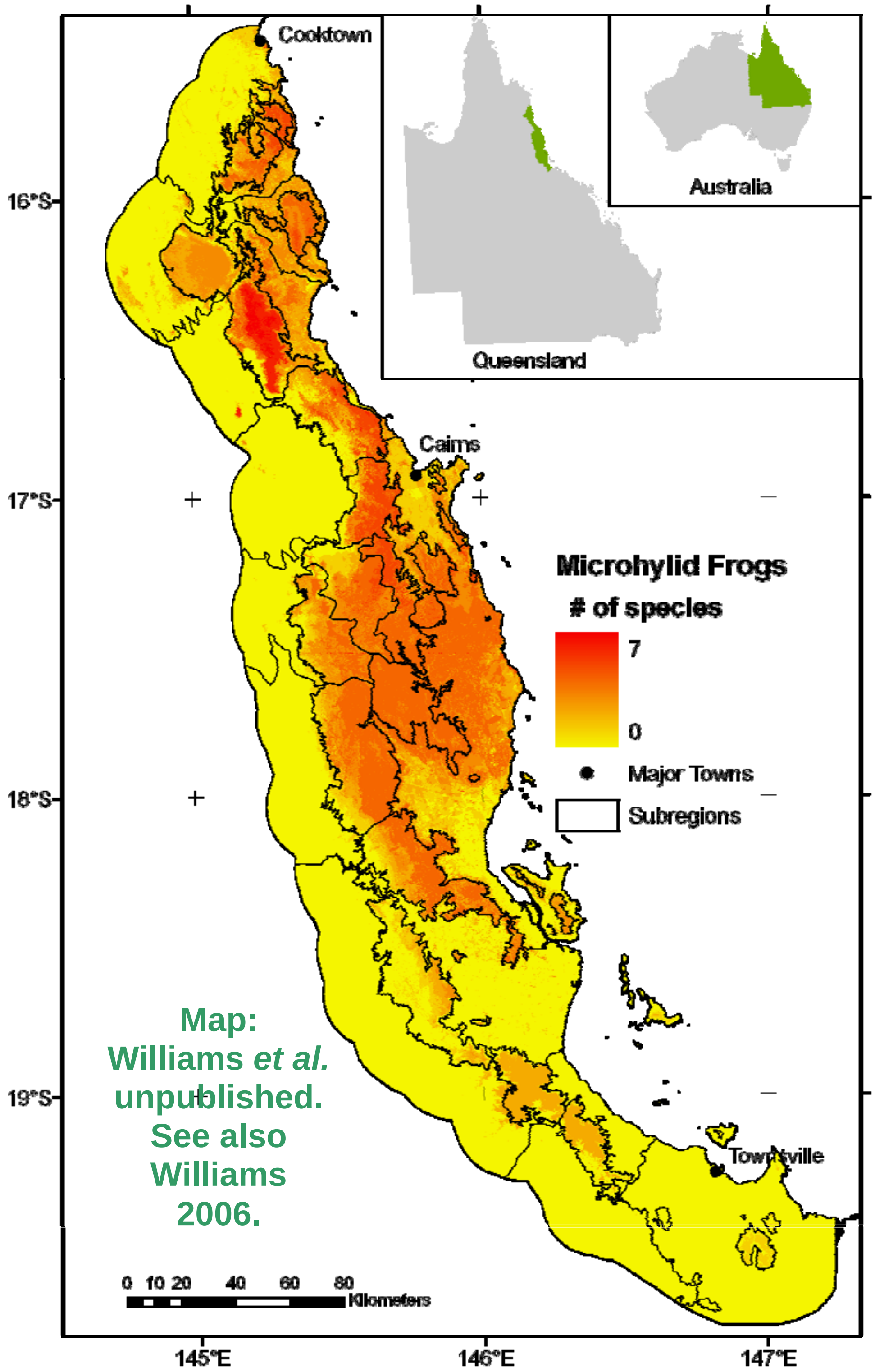

Figure 5: Rainforest microhylid richness based on overlapping distributions for microhylid species found in the rainforests of the Australian Wet Tropics.

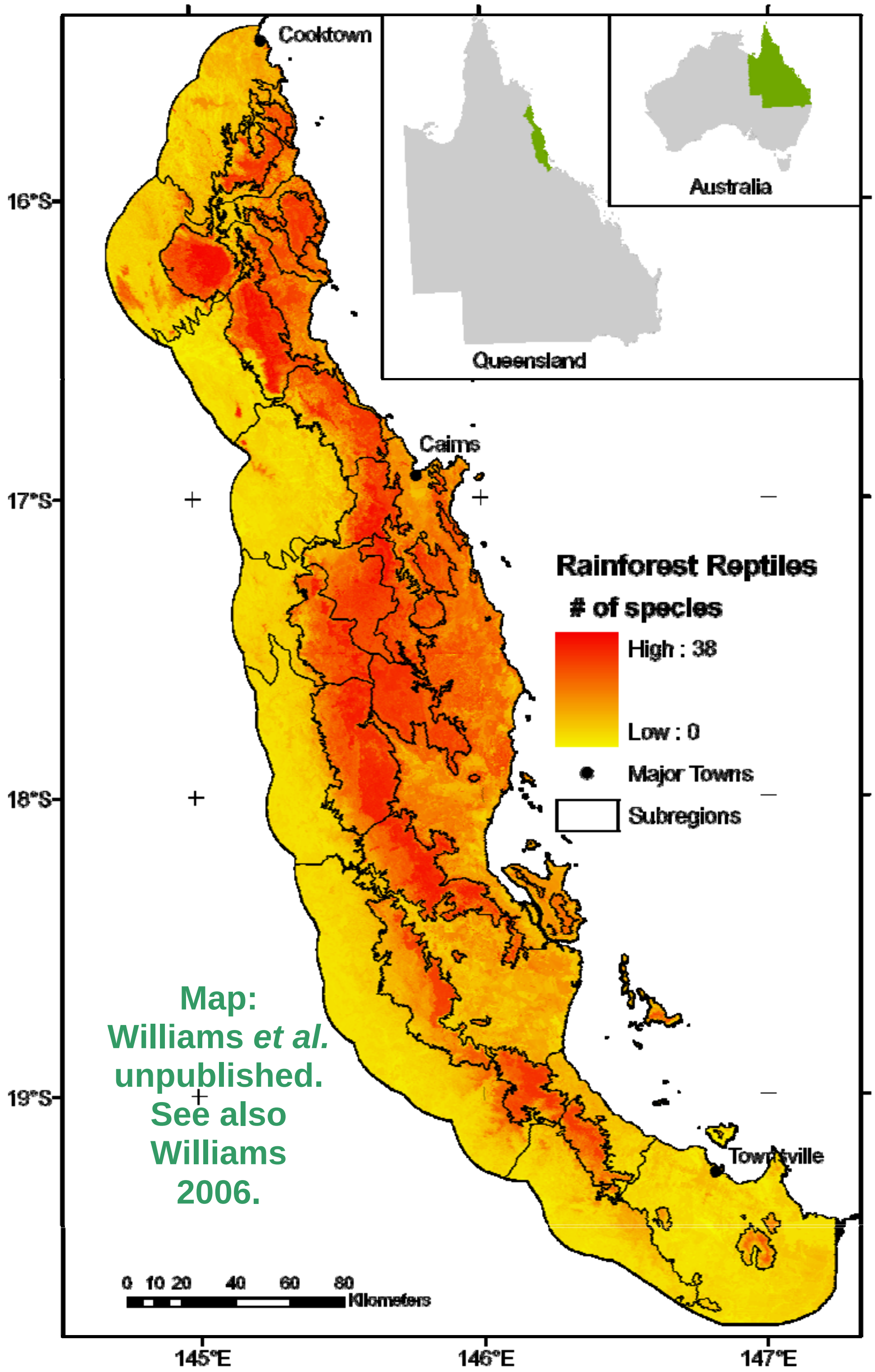

Figure 6: Rainforest reptile richness based on overlapping distributions for reptile species found in the rainforests of the Australian Wet Tropics.

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Communications, major activities or events

Centre for Tropical Biodiversity and Climate Change Annual Meeting
Gumburu, Paluma, 5-6 July 2007

Attendees – Steve Williams, Simon Robson, Richard Pearson, Yvette Williams, Jeremy VanDerWal, Joanne Isaac, Lucas Shoo, Brett Goodman, Sheree Fickling, Vanessa Valdez Ramirez, Marios Aristophanous, Anna McGuire, Scott Parsions, Rohan Wilson, Rob Puschendorf, Jeremy Little, Alex Anderson, Itzel Zamora Vilchis.

Apologies – Chris Johnson, Andrew Krockenberger, Johan Larson, Alex Kutt, Janette Kemp, Paul Williams, Steve Goosem, Ellen Webber, Peter Franks, Ivan Lawler, Nadine Marshall, Ross Alford, Lin Schwarzkopf, Steve Turton, James Maloney.

Welcome and agenda by Steve Williams

Day 1 and part Day 2 talks:

Marios Aristophanous: Altitudinal variation in the distribution, abundance and reproductive seasonality of the wet tropics dung beetle fauna (Coleoptera: Scarabaoidae: Scarabaeinae).

Rob Puschendorf: Predictive distribution models for the amphibian chytrid on opposite sides of the world: implications for amphibian conservation

Scott Parson: Soil processes, nutrient cycling and climate change in australian tropical rainforest

Simon Robson: Status of the ant/bat project

Luke Shoo: On the relationship between empirical field estimates of tropical forest aboveground primary productivity and climate

Anna McGuire: Climate, plant phenology and frugivory in the Australian tropical rainforest: the implications of climate change for the Wet Tropics bioregion

Joanne Isaac: Intrinsic sensitivity: which Wet Tropics vertebrates are most extinction-prone?

Brett Goodman: The roles of natural and sexual selection in defining ecomorphological relationships in tropical lizards: implications for climate change

Alex Anderson: Biodiversity and climate change: interactions between climate change, Net primary productivity and bird abundance and altitudinal distributions

Vanessa: Patterns and relationships between net primary productivity, vegetation types and climate change in the Wet Tropics World Heritage Area

Richard Pearson: Short talk on stream issues

Steve Williams: Assessing Vulnerability

Jeremy Vanderwal: GIS issues and using of the CTBCC database

Jeremy Little: Predicting Climate Change Impacts on Vegetation and Fire Regimes of North-eastern Australian Wet Tropics: Tropical Rainforest, Wet Sclerophyll Forest, Savanna Woodlands and their boundaries

Rohan Wilson: Effects of climate change on the Schizophoran communities of the Australian Wet Tropics rainforests

Day 2 discussion:

- Potential funding sources for expansion of projects were discussed.
- Implications of Suppiah Ramasamy's group's current climate change modeling was discussed for our region and projects.
- Potentials links between projects, overlap and data sharing was discussed for students.
- Dates of next meeting and place were given for July 2008.