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

Marine and Tropical Sciences Research Facility Final Milestone Report, June 2010

Program 5(ii): Climate Change: Rainforests and Catchments

Project 2.5ii.3: Understanding the climate change threat to ecosystems and ecosystem processes, and developing options for mitigation

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Summary

All project objectives have been completed, and final technical report completed:

Hilbert, D. (2010) *Threats to ecosystems in the Wet Tropics due to climate change and implications for management*. Report to the Marine and Tropical Sciences Research Facility (MTSRF). CSIRO Sustainable Ecosystems, Atherton (24pp.).

We used the artificial neural network classifier that was previously used to investigate the large expansions, contractions and spatial shifts of the environments of structural forest types in the Wet Tropics bioregion over the last 18-20,000 years, as well as changes due to one degree of future warming.

In this project, four scenarios were considered. In the worst-case scenario (IPPC A1FI), rapid warming (5°C) accompanied with reduced rainfall (-23%) by 2080, there are substantial decreases in the areas of environments that are characteristic of many important rainforest classes, although some increase. This analysis indicates, given the currently expected warming in this century, that the region's forests will be in a substantial disequilibrium with their environment. The large changes in the ecological environments of the bioregion will stress existing forest communities and ecosystems. Unfortunately, it is not possible to say where and when actual changes in forest structure and plant species composition will occur with confidence.

As the regional climate changes, the potential forest environments change spatially but, primarily because of soil and landform features, some areas may remain suitable for a certain vegetation type despite rather large changes in regional climate. These parts of the landscape, refugia, may be less impacted by climate change. Based on our methodology, refugia are not likely to be important at regional scales in the A1FI scenario except for some areas of Mesophyll Vine Forest environments in the central Wet Tropics.

Several clear ecological patterns are evident that correspond to changes in mean annual temperature across the project's plots. As mean annual temperature increases (decreasing elevation); forest basal area decreases and tree species endemism decreases although tree species richness and tree density do not change along the temperature/altitudinal gradient. These observations suggest a number of likely responses to global warming in the Wet

Tropics' forests, including reduced basal area (C stock) and possible expansion of generalist lowland species with concomitant decreases in more cool-climate adapted upland endemics. Based on a preliminary analysis of data from projects twelve plots, it appears that few tree species (approximately 10%) are altitudinal generalists while many species may be restricted to narrow altitudinal ranges (200m, which is equivalent to a 1°C range of mean annual temperature). This observation is quite significant, if supported by analyses of larger data sets, because it suggest that many tree species will rapidly be exposed to mean annual temperatures that are beyond their normal tolerances.

Mosquitoes, important vectors of wildlife and human disease, were captured across the project's altitudinal transect at three heights relative to the forest canopy and in three seasons over three years. Both the abundance and diversity of mosquitoes increase with estimated mean annual temperature of the plots. We recently identified Plasmodium (malaria) using PCR techniques in the most common lowland mosquito that was captured, *Coquillettidia crassipes*. This genus was recently reported to be a vector of avian malaria in Africa but has not previously been implicated as a vector in Australia.

DNA was successfully extracted from blood samples of 614 birds captured across the project's altitudinal transect and amplified for PCR analysis to identify DNA from haemoprotozoans. Infection by Haemoproteus is much more common than by Plasmodium and peaks at intermediate temperatures (and elevation) while infection rates of avian malaria (*Plasmodium relictum*) are highest in the warmer sites and decline to an average of approximately three percent at mean annual temperatures below about 22.5°C.

Project Results

Outputs of Project 2.5ii.3 are summarised in the above mentioned CSIRO technical report.

Maps of potential C stored in undisturbed rainforests in the Wet Tropics both now and with three degrees of warming are presented below.

Our plan is to submit numerous papers for journal publication in the coming year using results from this project.

The potential of rainforests to stock carbon in the Wet Tropics bioregion

Terrestrial ecosystems play an important role in slowing climate change by removing and storing carbon dioxide from the atmosphere and tropical rainforests are now estimated to remove an average of 1 Pg (10^{16} grams) of carbon (C) annually and store over 1000 Pg of C. However, our analyses suggest that the long-term capacity of tropical rainforest to store C is uncertain and is likely to decrease, as global warming proceeds, by approximately 24.5 Pg C per degree of warming. This decline is driven by temperature alone and does not include the possibility of further losses due to more uncertain reductions in rainfall over tropical regions. This project documented a pantropical pattern of lower biomass in warmer climates, estimated by basal area (BA, m^2 of tree stems ha^{-1} – the direct measure of above ground biomass and C stocks) that implies a reduced capacity of rainforests to stock C with global warming (see the above mentioned CSIRO technical report).

BA is negatively correlated with mean annual temperature, T (BA = 110.91-2.77 T, R^2=0.458, p=0.004). Using a model that predicts dry biomass from total BA (Baker *et al.* 2004) and assuming 50% carbon, we predict a reduction of the long-term carbon stock of 14.0 Mg C

ha^{-1} per degree (Celsius) of warming. Using these analyses we produced the following maps, restricted to areas that are now mapped as rainforest. Figure 1 maps potential C stocks today and Figure 2 maps potential C stocks after three degrees of warming.

For access to the spatial data, ArcMap grids, please contact the project leader: David.Hilbert@csiro.au.

Reference

Baker, T.R., Phillips, O.L., Malhi, Y., Almeida, S., Arroyo, L., Di Fiore, A., Erwin, T., Higuchi, N., Killeen, T.J., Laurance, S.G., Laurance, W.F., Lewis, S.L., Monteagudo, A., Neill, D.A., Núñez Vargas, P. Pitman, N.C.A., Natalino, J., Silva, M. and Vásquez Martínez, R. (2004) Increasing biomass in Amazonian forest plots. *Philosophical Transactions of the Royal Society B: Biological Sciences* 359: 353-365.

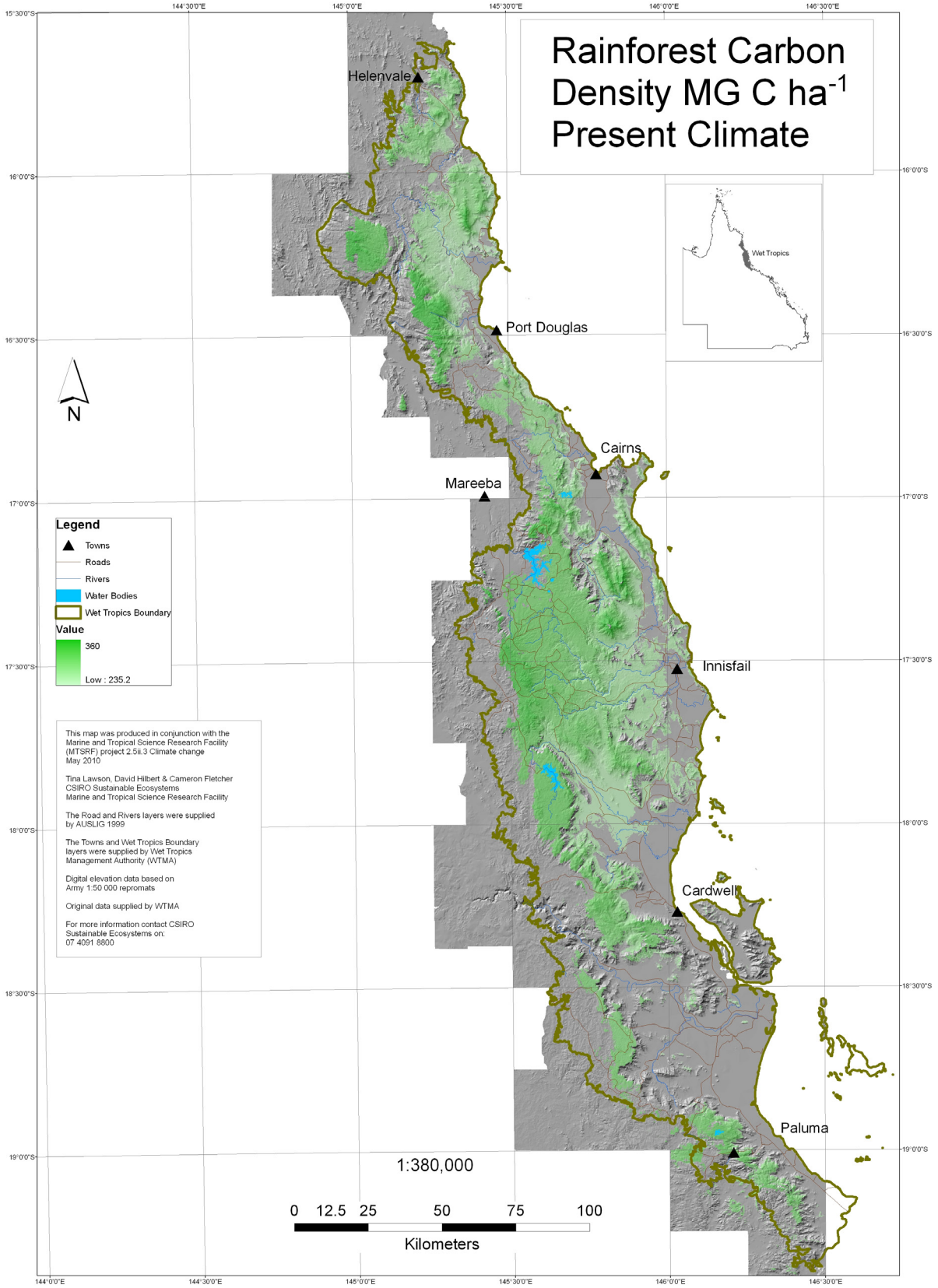

Figure 1: The potential C stock of rainforests in the Wet Tropics bioregion in the current climate. Note that the colour scaling is 235-360 MG C ha^{-1}.

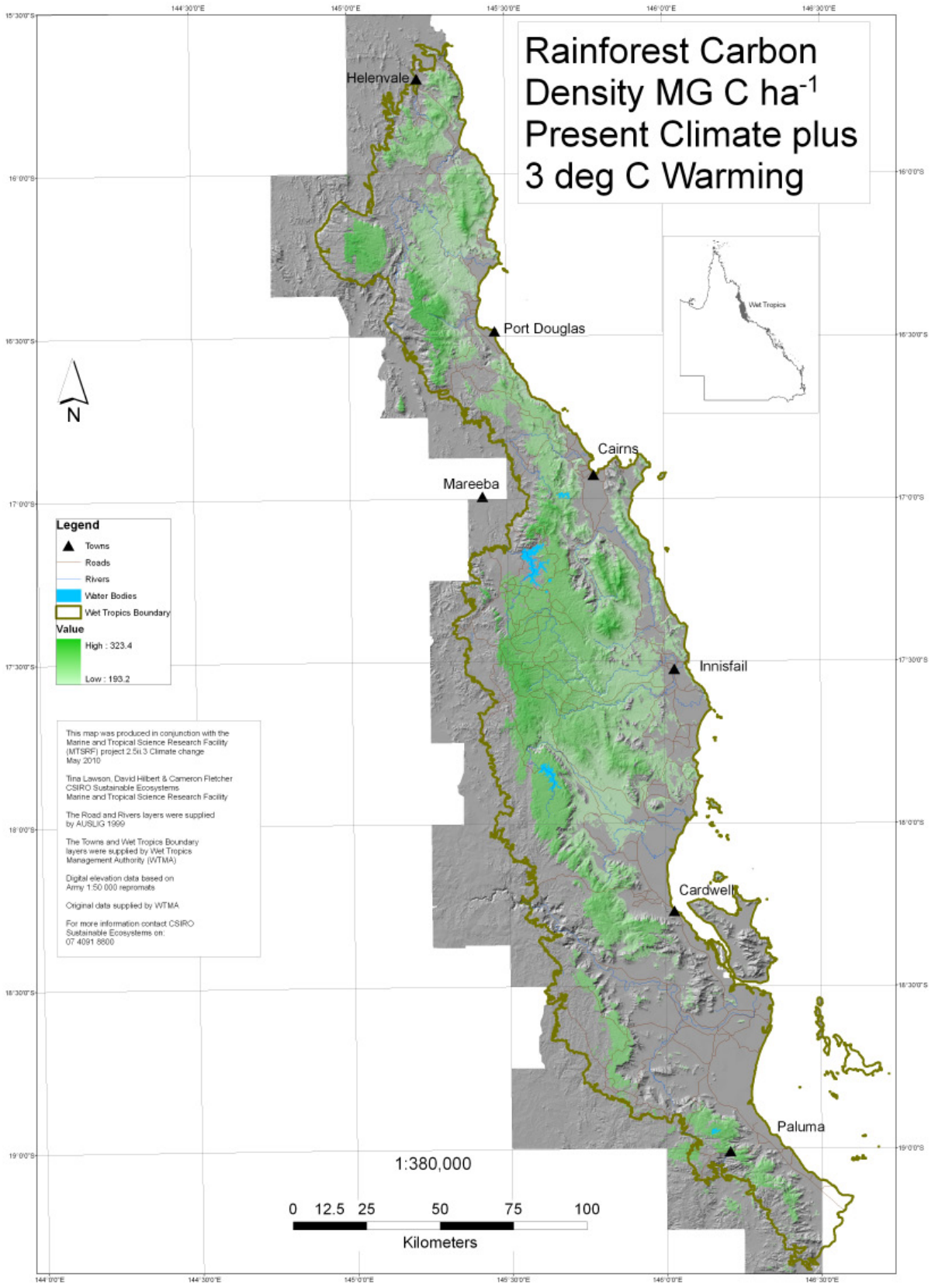

Figure 2: The potential C stock of rainforests in the Wet Tropics bioregion after three degrees of warming. Note that the colour scaling is now 193-324 MG C ha^{-1}.