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Global Warming in the Wet Tropics

Issues in Tropical Forest Landscapes

High altitude cloud forest in the Wet Tropics (photo: Wet Tropics Management Authority)

Rainforest CRC

Humans are rapidly changing the nature of our planet in profound ways. Global changes include alterations to the vegetation cover of the land, the chemical composition of the earth's atmosphere, global climate and climate variability, and the rapid and extensive introduction of exotic species.

Australia's Wet Tropics are dominated by mountain ranges giving extremes of altitude from sea level to around 1600 metres. Most remaining rainforest in the Wet Tropics is above 300m and almost all species unique to this region are adapted to these cooler uplands. Temperature rises due to global warming would mean massive changes to these cool uplands, leading to loss of habitat. Consequently, the biological diversity and endemic species that are the keystone of the Wet Tropics World Heritage Area are under severe threat.

Ecosystem processes and the provision of ecosystem services could also be severely affected by climate change, indicating how imperative it is to understand the processes that shape large scale regional ecological patterns over time. Only then can predictive tools be developed to enable realistic conservation planning for the unique ecosystems of the Wet Tropics and other rainforests in Queensland.

Climate Change is variation in either the average state of the climate or in its variability. It encompasses temperature increase – or global warming, rises in sea-level, changes in patterns of precipitation and increases in the frequency of extreme weather events persisting for decades or longer.

What is changing the climate?

The earth's climate is regulated by the natural greenhouse effect, created by an atmosphere containing greenhouse gases like carbon dioxide and methane that trap heat from the sun.

The global heat balance has been changed by human use of fossil fuels such as coal and oil, which release greenhouse gases when burned. By depending on the combustion of fossil fuels for energy, manufacturing and transport and through the broadscale clearing of forests, humans are creating an extra blanket around the earth.

IPCC (Intergovernmental Panel on Climate Change) research suggests:

- Concentrations of atmospheric CO_2, the main greenhouse gas, have increased from pre-industrial levels of 280 ppm around 1750 to 367 ppm in 1999.
- Without a reduction in the use of fossil fuels, CO_2. concentrations will reach 650 ppm by 2100.
- Concentrations of methane, another very potent greenhouse gas, have more than doubled from c. 750 ppb in 1800 to 1,745 ppb in 1998.

Warming over land in the Southern Hemisphere for 1901 to 2000 is estimated to have been about 0.5°C.

Direct effects of global warming

The best possible projections for global warming in the tropics are for an increase of between 1.4 and 5.8°C by 2100. While rainfall will increase in a warmer world, climate models project considerable regional variation. Scenarios for areas as small as the Wet Tropics uncertain are uncertain although several models predict:

- A +4 % to -10 % change in rainfall in northern Queensland for every degree of global warming.
- More frequent El Niño type conditions for the Pacific through this century and a possible increase in tropical cyclone intensity. El Niño conditions normally cause lower rainfall and longer dry seasons in the Wet Tropics.
- A rise in sea levels of up to about 90 cm by 2100 due to the slow warming and consequent thermal expansion of the oceans.
- Greater frequency and severity of heat wave conditions.

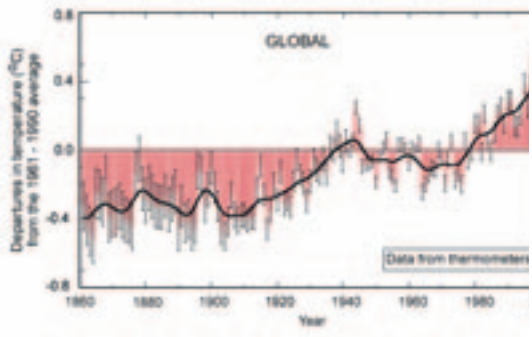


Figure 1. The 1990s was the warmest decade eve recorded instrumentally. The last 100 years were th warmest of the millenium, with 1998 the hottest yea on record and 2002 the second hottes

Ecological and biological effects

The lack of any climate change monitoring in the Wet Tropics makes it impossible to state whether warming in this century has had any impact on its flora or fauna or ecosystem processes. However, monitoring in other parts of the world has identified a large number of ecological and biological changes due to recent climate change. These include:

- Both latitudinal and altitudinal shifts in species ranges.
- Changes in abundance and local extinctions.
- Changes in growing season length.
- Earlier flowering, emergence of insects, migration and egg-laying in birds.
- Changes in morphology (e.g., egg and body sizes).
- Breakdown in symbiotic relationships.

LIST OF UPLAND SPECIES AFFECTED BY CLIMATE CHANGE

This lists the most vulnerable species of endemic vertebrates, those that are predicted to lose greater than 50% of their current area of core environment with only a 1°C increase in temperature.

FROGS	
Thornton Peak Nursery-Frog	*Cophixalus sp Thornton Peak*
Magnificent Broodfog	*Pseudophryne covacevichae*
Pipping Nursery-Frog	*Cophixalus hosmeri*
Northern Barred Frog	*Mixophyes sp. Nov.*
Tangerine Nursery-Frog	*Cophixalus neglectus*
Bloomfield Nursery-Frog	*Cophixalus exiguus*
Mountain Top Nursery-Frog	*Cophixalus monticola*
Northern Tinkerfrog	*Taudactylus rheophilus*
MAMMALS	
Atherton Antechinus	*Antechinus godmani*
Mahogany Glider	*Petaurus gracilis*
Daintree River Ringtail Possum	*Pseudochirulus cinereus*
Lemuroid Ringtail Possum	*Hemibelideus lemuroides*
Herbert River Ringtail Possum	*Pseudochirulus herbertensis*
Spotted-tailed Quoll	*Dasyurus maculatus*
SKINKS	
Thornton Peak Skink	*Calyptotis thorntonensis*
Bartle Frere Skink	*Techmarscincus jigurru*
Czechura's Litter Skink	*Saproscincus czechurai*
Saproscincus lewisi	*Eulamprus frerei*
Lampropholis robertsi	*Glaphyromorphus mjobergi*
BIRDS	
Golden Bowerbird	*Prionodura newtoniana*
Atherton Scrubwren	*Sericornis keri*
Mountain Thornbill	*Acanthiza katherina*

Effects on habitat

Warming can have a particularly strong impact on mountainous regions like the Wet Tropics where the mountain tops and higher tablelands exist as cool islands in a sea of warmer climates. These islands are separated from each other by warmer valleys and form a scattered archipelago of habitat for organisms that are unable to survive and reproduce in warmer climates. Many of the Wet Tropics endemic species live only in these cooler regions.

Figure 2 shows the geographic distribution of habitat with mean annual temperatures less than 22 °C in the Wet Tropics. This is approximately the upper temperature threshold for many arboreal leaf-eating animals (folivores), such as possums and tree kangaroos that occur in the Wet Tropics. The decrease in habitat area is as remarkable as the increase in fragmentation. Smaller patches of habitat are known to decrease and fragment populations thereby increasing the risk of extinction.

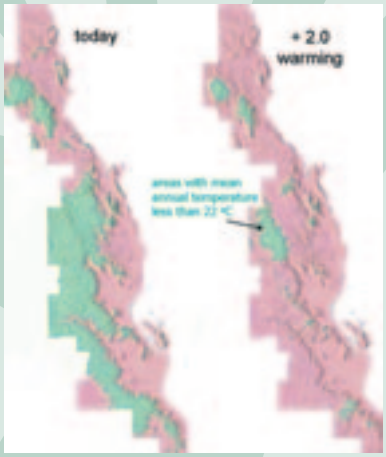


Figure 2. Areas in the Wet Tropics with mean annual temperatures less than 22°C (green) in today's climate (left) and after 2°C warming

Likely effects on the Wet Tropics

Rainforests

The extent and distribution of forest types in the future is an important indicator of potential changes in biodiversity. Models developed by Rainforest CRC researchers show that the tropical forests of north Queensland are highly sensitive to climate change.

The location and extent of rainforests is determined by rainfall and its seasonality, with some influence of soil fertility and water-holding capacity. But the type of rainforest and the organisms found there depend more on temperature. In the Wet Tropics, one degree of warming could increase the potential area of rainforests as a whole, as long as rainfall does not decrease. However, even with the exact same rainfall and rainfall pattern, higher temperatures increase evaporation so that effective dryness will also increase. Large changes in the distribution of forest environments are likely with even minor climate change and the relative abundance of some forest types could decrease significantly. Increased rainfall favours some rainforest types while decreased rainfall increases the area suitable for woodlands and forests dominated by tough-leaved plant genera like *Eucalyptus* (gums), *Allocasuarina* (she-oaks) and *Acacias* (wattles).

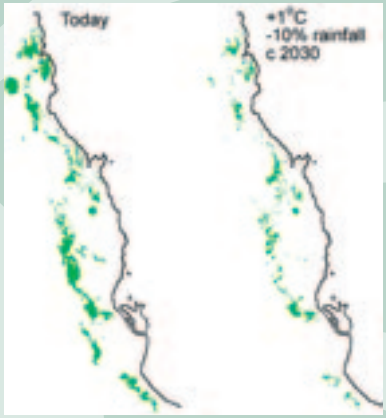


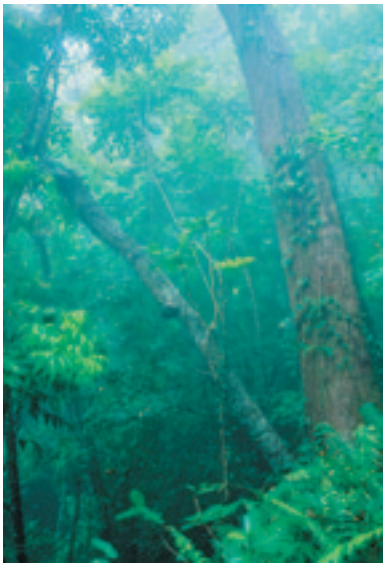
Figure 3. Distribution of highland rainforest environments today (left) and their potential distribution after an increase in temperature and a decrease in rainfall (right).

While lowland forests will likely expand in area, highland rainforest habitats of many of the region's endemic vertebrates, including fern forests and thickets, will decrease by 50 % with only a 1°C warming. Using this model CRC researchers have mapped the current and potential future distributions (1°C warming and -10 % rainfall) of upland and highland rainforest types in Figure 3.

Environments suitable for these forest types decline greatly and become highly fragmented in this climate change scenario. At 5.8 °C, the upper range of predicted warming, no appropriate environments would remain within the Wet Tropics. Whether and where appropriate climates might come to exist further to the south in areas like the Border Ranges, is unknown. Regional rainfall patterns and topographic constraints however, imply that such new habitat would be very far removed from that of the Wet Tropics.

Cloud Stripping

Cloud forests are sensitive to climate changes. One likely effect of warming is a significant lifting of the base of the cloud-bank on tropical mountains. Cloud stripping, or the trapping of cloud water droplets by cloud forests, can significantly augment rainfall, especially in the dry season. Global climate simulations with doubled CO_2 show that the relative humidity surface is shifted upwards on tropical mountains by hundreds of metres during the winter dry season. This is the period when these forests are most reliant on the moisture from cloud contact. Because of their great sensitivity to climate, cloud forests are likely to display effects from climate change in the very near future. Cloud forests in Costa Rica have already experienced the loss of endemic frogs and changes in bird and mammal communities.



The atmosphere inside a highland cloud forest (photo: Wet Tropics Management Authority)

Vertebrates

The Wet Tropics forests are home to over 560 species of vertebrate animals. The entire region is likely to undergo ecological changes as the climate warms but small temperature increases will threaten highland forest environments on the top of mountains like Bartle Frere, Bellenden Kerr and Thornton Peak. Most Wet Tropics vertebrates do not experience a wide range of temperature within their distribution. For example, annual mean temperature for the Windsor Nursery Frog (*Cophixalus bombiens*) only varies by 1.8 °C, and even for a widespread species like the Leaf-tailed Gecko (*Saltuarius cornutus*) the range is only 9 °C. On average the range of annual average temperature across regionally endemic species is just 5.5° C, indicating the significance of a temperature rise of several degrees. Environmental models of spatial distributions across all of the endemic vertebrates suggest that global warming will have severe effects on the long-term survival of many species. A one degree increase is considered a certainty and even this small increase is predicted to decrease the range of endemic species to an average 63 % of their current range size and cause the habitat of one of at least one frog species to disappear.

With larger increases in temperature, the preferred habitat of a number of high altitude species will completely disappear and possibly drive these species to extinction. A mid-range prediction, such as the 3.5°C figure put forward by the Intergovernmental Panel on Climate Change, will reduce range sizes to an average 11 % of their current area, completely removing the current habitat of about 30 endemic species. This represents the loss of almost half of the unique animals that are a crucial element of Wet Tropics biodiversity. It implies the very real possibility of about 50 species going extinct – an environmental catastrophe associated with only a moderate prediction of climate change. Most upland species will disappear under the worst case scenarios with temperature increases of 5°C or more.

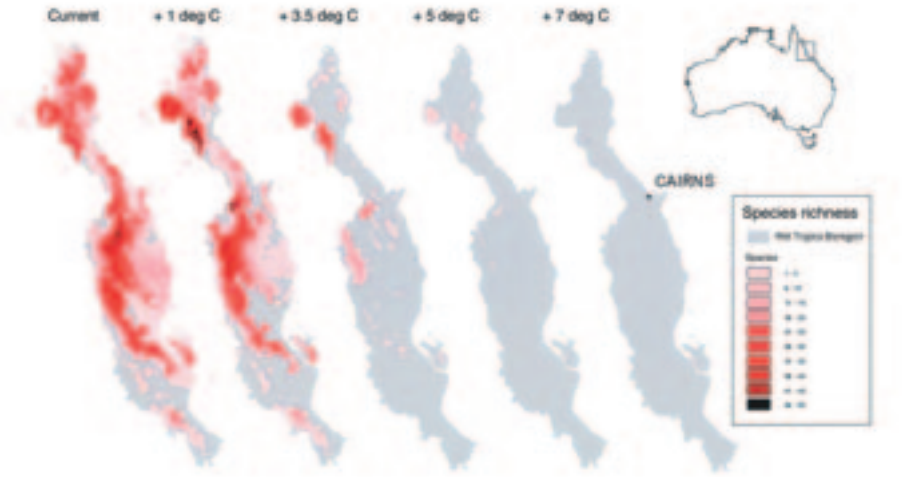


Figure 4. Indicates the change in distribution of species richness of regionally endemic terrestrial invertebrates with increasing temperature.

Additional effects of climate change

Predicted effects will conceivably be much worse when changes other than the increased temperature, are also considered. A number of other effects are likely to occur in the Wet Tropics as a result of global change. These include:

- Increased CO_2 levels will reduce the nutritional value and increase the toughness of most foliage. This could have significant detrimental effects on folivore abundance (endemic ringtail possums and many insects for example).
- Predicted changes in geographic distribution will push species off nutrient-rich, basaltic soils and onto increasingly poorer granitic soils at higher elevations. Rainforest CRC research has shown that forests on these poorer soils support lower population densities of arboreal folivores.
- Increasingly, unpredictable rainfall may have significant effects as well. The populations of many species already experience bottlenecks in resources during the dry season. If the length or severity of the dry season increases as predicted, this bottleneck will increase and put more stress on these populations.
- Raised cloud bases will affect species requiring high and consistent moisture levels (directly affecting microhylid frogs, litter skinks, soil invertebrate faunas, and soil microbes) and thereby all litter-feeding insectivores.

(photos: Steve Williams)

- Longer dry seasons will probably affect both fruiting biomass and phenology. Changes to these processes will undoubtedly cause many flow on effects across the tropic levels (eg. fruit biomass decline might result in declines in frugivores that in turn will affect seed dispersal and recruitment processes).
- Ecosystem disturbance and increased vulnerability to invasion by feral animals, weeds and pathogens.
- Changes in fire regimes.

(photos: Steve Williams)

Fire controls much of the boundary between rainforest and sclerophyll forests and in the El Niño event of 2002/2003 fires encroached on Wet Tropics rain forest types previously thought to have been untouched. El Niño increases and associated drought is likely to increase the frequency and severity of unusual fire years and may lead to large changes in the distribution of some of the dryer rainforest types close to the sclerophyll boundary.

(photos: Steve Williams)

Research needs

Future research must provide the critical information and tools to develop management plans aimed at conserving forest ecosystem processes and biodiversity in the face of rapid, unprecedented climate change. It is widely recognised that in order to understand large-scale patterns it is necessary to integrate knowledge from molecular biology, physiology, ecology, biogeography, remote sensing, spatial modelling, evolution and climatology.

Critical gaps in knowledge

For the most part, however, we still do not know what is threatened, where the threats are greatest, the long term effects of these threats, how climate change will interact with other threats such as clearing, weeds, and feral animals, and whether some areas will continue to provide habitat or new areas of habitat in the future. Particularly important information gaps include:

- A quantitative understanding of climatic and edaphic controls on upland rainforest types and their potential distributions under climate change.
- Knowledge of the distributions and climatic requirements of most highland species or how they will be affected by climate change.
- The sensitivity of highland species to reduced cloudiness.

- The geographic extent and location of suitable habitats for various species, including many endemics, with climate change.
- Whether some locations will act as refugia in the coming much warmer climate.
- Whether current conservation boundaries and off reserve policies will be effective with increasing warming and other climate changes.
- Areas where interactions among global change drivers (climate change, clearing, invasions, and elevated CO_2) are particularly threatening

Management considerations

Climate change is a global phenomenon, driven by global patterns of energy use and deforestation. Management policies can and must be developed to minimise these negative impacts. It is possible that climate change will also present some opportunities and, if so, these must be known and managed as well.

The impacts of global climate change will depend on two factors: 1) the final, realised degree of change and 2) the resilience of the ecosystem in question. The first factor can only be addressed globally and at a governmental level by reducing global greenhouse gas emissions. However, the second issue, of resilience, can be addressed locally.

Successful long-term conservation of the Wet Tropics World Heritage Area will be dependent upon a number of management issues and actions which cannot be discussed or implemented before research has begun to fill the current gaps in information. These include:

- Decision-making on a large, biogeographic scale and including land outside reserves. It is possible that suitable habitat for many Wet Tropic species will only occur thousands of kilometres to the south in 50 to 100 years time. Managers need to know where this habitat might occur and begin considering the implications of such changes.
- Assuming that research identifies regions within the Wet Tropics that might act as greenhouse refugia (restricted regions where biota can survive despite warming), protecting and managing these areas now to enhance their stability for the future.
- Connecting suitable habitat areas to minimise the interacting effects of other, more tractable, global change processes (i.e., land clearing, linear barriers, weeds and feral animals).
- Active management of individual species that are most threatened by warming must be considered. The possibility and desirability of translocating species to distant suitable areas in the future must be debated in the present.
- Understanding the factors affecting ecosystem resilience.

Resilience refers to the ability of a system to recover from disturbance and is a key management concept in dealing with an unpredictable future. In order to maximise ecosystem resilience, we need to maintain ecological processes and minimise any action that may damage the inherent resilience of the ecosystem such as loss of biodiversity, habitat fragmentation, feral animals, weeds and diseases.

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