How Will Global Change Affect Tropical Forests?
Recent Findings and Debates

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Rising CO₂ levels

![Graph showing rising CO₂ levels from 1800 to 2000. The graph plots carbon dioxide (ppmv) against the year. The data is represented by blue dots labeled "Ice cores" and red squares labeled "Mauna Loa." The graph illustrates a significant increase in CO₂ levels, particularly after 1950.](image)
CO₂ Increases are Accelerating

Annual increase (ppm)

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<td>Annual increase (ppm)</td>
<td>0</td>
<td>0.5</td>
<td>1.0</td>
<td>1.5</td>
<td>2.0</td>
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Rising Temperatures

Global temperature anomalies (1850-2007)
Many Other Global- and Regional-scale Changes

- Massive land-use changes
- Shifts in precipitation
- Changes in cloudiness and insolation
- Increased nutrient deposition
- Air and water pollution
- Legacy of past disturbances

Northern Bolivia
Known or Hypothesized Effects of Rising Temperatures
1) Declines of high-elevation biota

- Many elevational specialists in tropics
- High endemism

Central Panama

Western Ghats, India
Australia’s tropical rainforests

- Tiny, relictual distribution
- 0.3% of the continent’s land area
Many Upland Endemics
Bioclimatic Models of Future Warming

Even modest warming (1°C) and drying (10%) could dramatically reduce & fragment cool upland forests

D. W. Hilbert et al. (2001) *Austral Ecology*
Projected Habitat Declines for the Golden Bowerbird, an Upland Endemic

S. E. Williams & D. W. Hilbert (2006), in *Emerging Threats to Tropical Forests*, Univ. of Chicago Press.
Projected Vertebrate Extinctions in Tropical Australia

S-curve fit:
adj. $r^2 = 0.997$
$p = 0.001$

Sharp acceleration above $2^\circ C$ →

IPCC prediction range

S. E. Williams et al. (2003)
Proc. Roy. Soc. B.
2) Increasing pathogen impacts


Chytrid fungus

- Chytrid-driven extinctions of Andean harlequin frogs mainly occurred in warmer years (>100 species)

Laurance (2008) *Austral Ecology*

- Similar patterns among Australian rainforest frogs (14 species)
3) Temperature-related stress and mortality

Welbergen et al. (2007)  
*Proc. Roy. Soc. B.*

- 12 January 2002, heat-wave (>42°C) in E. Australia
- Animals exhibited extreme panting, wing flapping, stress
- Over 3500 died in 9 colonies
- Little black flying foxes most vulnerable, especially young and females
- At least 19 similar die-offs since 1994

![Mortality threshold graph](image)
4) Declining forest growth

- Night-time temperatures rising fastest in tropics
- Should increase plant respiration and possibly decrease growth
- May reduce carbon storage → forests become carbon source

Feeley et al. (2007) Ecology Letters
- Declining tree growth at BCI and Pasoh
Known or Hypothesized Effects of Rising CO$_2$ levels
1) Increasing forest dynamics & carbon storage

- Increasing forest turnover
  - Phillips & Gentry (1994) *Science*

- Increasing growth & productivity

- Increasing NDVI

- Increasing biomass
  - Phillips *et al.* (1998) *Science*

- Whole-forest C sink
  - Grace *et al.* (1994) *Science*

2) Changes in forest composition

- Increasing liana densities

- Alterations in tree-community composition

![Graph showing changes in liana density and tree community composition](image)

\[ R_s = 0.315, P = 0.0006 \]
3) Declining evapotranspiration
Known or Hypothesized Impacts on Tropical Climates
All models predict rising temperatures, but vary in magnitude.
2) Altered precipitation patterns

Predictions vary greatly, especially at finer scales

- differing trends
- differing hotspots of vulnerability

Precipitation Anomalies (mm/day) for 2070-2099

Low GHG Scenario

High GHG Scenario
3) Increasing weather extremes

- Storms, floods
- ENSO droughts
- Great uncertainty

Aftermath of Cyclone Larry, north Queensland, 2006
Known or Hypothesized Synergisms with Land-use

Fires and deforestation near Xingu National Park, Brazilian Amazonia
1) The island effect

Rondônia, Brazil

Central Panama
2) Escalating fires

Vast areas of the tropics are already near the physiological limits of rainforest...

Percentage of years with drought

...and forest disruption increases desiccation

...and ignition sources have multiplied dramatically