Human impacts on forest responses to climate

Outline of the Earthwatch-HSBC Climate Partnership Research Programme

Aim

The aim of the programme is to quantify how human disturbances affect the responses of forests to climate change.

This will help forest managers and communities to maintain diverse and productive forests in the future. The data will also inform vegetation dynamics models that predict future changes in forest composition and carbon content.

Rationale

Billions of people around the world rely on trees and forests for the diverse ecosystem services they provide. These services are potentially threatened both by unsustainable use and by climate change. Almost all forests have been modified by humans in some way, and all will be affected by climate change. Therefore, the effects of climate change on forests cannot be considered in isolation from the influences of human disturbances. For example, it is known that many tropical forests become prone to drought and fire when the canopy is opened by logging. The interaction between disturbance and climate for other forest types is poorly understood.

Human disturbances may interfere with soils and disrupt important mycorrhizal networks, or open the forest canopy and increase penetration of wind and sunlight into the understorey. More trees may blow down in storms, and more forest fires may start during droughts, in disturbed versus undisturbed forests. Disruption of leaf or reproductive phenology could affect herbivores and pollinators that rely on trees for food.

Climate models predict increasing average global temperatures, and changes in the frequency and intensity of extreme events such as droughts, floods, and storms. Human disturbances of forests are likely to increase their susceptibility to climatic stresses. Human impacts include harvesting of trees and non-timber forest products, fragmentation into small patches of forest, or plantation management.

Disturbance-climate interactions are being studied in five field centres around the world.

Study sites

UK: Wytham Wood, Oxfordshire

Oxfordshire has low forest cover, with a highly-fragmented distribution. Wytham Wood comprises a 400 ha mosaic of semi-natural and plantation woodland, surrounded by copses, hedges, and individual trees. Research teams from the University of Oxford and the Centre for Ecology and Hydrology are studying the relationship between fragmentation and the responses of trees and animals to climate.

USA: Chesapeake Bay, Maryland

The Smithsonian Environment Research Centre comprises 1100 ha of forest, cropland, pasture, freshwater wetlands, tidal marshes, and estuaries around the Rhode River. The forests, with a large component of tulip poplar (*Liriodendron tulipifera*), represent a variety of successional stages following abandonment of agricultural fields. The aim is to quantify the relationship between successional stage and response to climatic variables, and also the impact of partial

stand harvests. Another project is investigating the roles of herbivores (deer) and invasive plant species in affecting forest regeneration.

Brazil: Mata Atlantica, Paraná

The Atlantic Forest of Brazil has been defined as a *biodiversity hotspot*, with high endemism of vascular plants (~8000 endemics) and high human impact (< 10 % original cover remaining). Remaining forests are fragmented to varying degrees, and in varying stages of succession following disturbances. SPVS, a non-governmental organization, is studing the effects of human disturbance on responses of trees and pollinators to climate.

India: Western Ghats, Karnataka

The Western Ghats range is another biodiversity hotspot, with 3049 endemic plant species but only 22% of original vegetation remaining. The Sirsi region of Uttara Kannada district is interesting for the high human population density, with many communities relying heavily on forest products and agroforestry. There is also a very strong rainfall gradient producing different forest types in a small area. The Centre for Sustainable Technology of the Indian Institute of Sciences is studying vegetation dynamics in moist forest, dry forest, and teak plantations. Agroforestry systems are also being investigated.

China: Gutianshan, Zhejiang

The Gutianshan National Nature Reserve, approximately 81 km^2 in area, is located in Kaihua County, at the extreme west of Zhejiang Province, East China. The reserve contains logged and undisturbed evergreen broadleaved forest, and nearby plantations. The Institute of Botany, Chinese Academy of Sciences, has already enumerated an 18 ha permanent sample plot in least-disturbed forest, and has established a network of smaller plots in secondary forests and plantations.

Methods

The responses of trees and animals to climatic variability are being studied in forest stands that differ in the quantity or quality of human disturbance. The type of disturbance depends upon the management history of each region, and includes harvesting method and intensity, extraction of non-timber forest products, forest fragmentation, and plantation forestry. Regeneration following cutting leads to forests of different ages, therefore the influence of successional stage on forest responses to climate change is also of interest.

The research programme is designed to capture two components of predicted climate change: long-term trends and short-term variability. Trends are continuous directional changes (e.g. global warming), while variability refers to increasing temporal variance in climatic parameters (e.g. floods and droughts).

Tree dynamics

The programmes are based around 1 ha permanent sample plots, in which various components of forest dynamics are recorded, in relation to climatic variables.

1. **Permanent sample plots**. To monitor long-term trends in forest structure and composition, a network of 1-ha plots has been established in forest stands that vary according to the disturbance mode under investigation. All trees with diameter > 5 cm are identified to species, mapped, and diameter recorded. Methodology follows that of the Center for Tropical Forest Studies (CTFS). Enumeration will take place every 3 – 5 years.

2. **Coarse woody debris**. To monitor long-term trends in forest-floor carbon, the location, decay class, and volume of coarse woody debris (> 5 cm diameter) are enumerated in each permanent sample plot. Enumeration will take place every 3 – 5 years.
3. **Dendrometer bands**. To monitor the effects of climatic variability on tree growth, dendrometer bands are attached to a subset of trees > 10 cm dbh, in each permanent sample plot. Materials and methods for cost-effective dendrometer bands have been developed by the Environmental Change Institute (Oxford University) and CTFS. Enumeration will take place every 1 – 3 months, depending on tree growth rates in the study area.
4. **Phenology**. To monitor the effects of climatic variability on tree phenology, litter (leaves, fine woody debris, reproductive structures) are collected using litter trap. Litter is sorted, dried, and weighed. Leaf-flush dates are recorded for temperate and seasonal forests. Litter traps are collected every 2-4 weeks.

Animal population dynamics

In the UK, and additional project on animal population dynamics has been funded.

1. **Invertebrate diversity and phenology**. Insect groups such as Lepidoptera are trapped and identified in different forest types through the season, to understand the effect of forest disturbance on diversity and distribution. In the long term, effects of climate will be discernible.
2. **Migration of small mammals through fragmented habitat**. Mark, release and recapture will be used to monitor movement of small mammals among habitat patches, to model ability of species to migrate in response to climate change.
3. **Litter decomposition**. The role of invertebrates in litter decomposition is being studied using litter bags that exclude different groups.

Climate

1. **Microclimate**. Collect microclimatic data (soil temperature) within plots using automatic sensors. At least 3 sensors are placed per plot.
2. **Weather**. Collect continuous meteorological data (precipitation, min/max temperature, wind speed) using automatic weather station.

Outputs

Earthwatch and the Smithsonian Tropical Research Institute are organizing a symposium ("Taking Stock: HSBC Climate Partnership Science Mid-Term Review"). The symposium, to be held in March 2010, will summarize scientific results from Earthwatch and STRI field teams.

The end-of-programme conference will be held in 2012.