Figure 1 | Not the source. Atmospheric carbon dioxide concentrations rose rapidly during the last glacial termination, with some researchers suggesting that the Southern Ocean was the conduit. De Pol-Holz and colleagues[4], however, have found evidence against this interpretation.

its radiocarbon activity declined[1,2]. This would suggest that the atmospheric carbon dioxide came from a source that had been isolated from exchange with the atmosphere for thousands of years. A recent study by Marchitto and co-authors[3] documented anomalously low radiocarbon activity in fossilized calcite shells of foraminifera (Protozoa) that lived in the intermediate waters of the northeastern Pacific during the last glacial termination. The drop in radiocarbon activity coincided with climate warming and the atmospheric carbon dioxide rise.

The anomalies were therefore interpreted to reflect the release of carbon dioxide that had accumulated in the deep ocean during the ice age. Because intermediate water in the northeastern Pacific orignates at high southern latitudes, Marchitto and co-authors suggested that the old carbon was released from the deep sea through the Southern Ocean[3].

De Pol-Holz and colleagues[4] reasoned that because Antarctic Intermediate Water flows along the southern margin of Chile at intermediate water depths this would be an ideal location to test Marchitto and co-authors' hypothesis. They compared radiocarbon activity of the fossil shells of both bottom- and surface-dwelling foraminifera from individual core samples. This comparison allowed them to constrain the radiocarbon activity of Antarctic Intermediate Water at this location. Rather than finding an anomaly in radiocarbon activity as observed in the northeast Pacific, they found that radiocarbon activity remained stable throughout the last deglaciation. In fact, the radiocarbon activity of the intermediate water closely followed that of the surface ocean, with an appropriate correction for a reservoir effect. In other words, there is no indication that old carbon was released to intermediate waters and to the atmosphere through a Southern Ocean pathway.

This finding comes soon after other unsuccessful attempts to locate a place in the deep ocean where metabolic carbon dioxide remained isolated from the atmosphere for thousands of years during the last ice age[5]. In light of De Pol-Holz and colleagues' results[4], it now seems highly unlikely that renewed ventilation of deep waters through the Southern Ocean (Fig. 1) can explain the recurrent pattern of deglacial carbon dioxide rise during each glacial termination. ❐

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ECOLOGY

Tropical teleconnections

At the end of the twentieth century, tropical deforestation was associated with the growth of rural populations. An assessment of the factors involved in forest loss suggests that today's trees are more likely to be affected by economic pressures from farther afield.

J. A. Cardille and E. M. Bennett

The world's expanses of forest are shrinking fast. The problem is particularly acute in the tropics, where swathes of forest are destroyed each year. The loss of tropical forests has resulted in a host of social and environmental problems, including the displacement of indigenous people, the loss of biodiversity and the emission of greenhouse gases. Indeed, deforestation is thought to account for nearly 20% of the greenhouse gases entering the atmosphere each year[1]. In the latter part of the twentieth century, deforestation was driven largely by rural population growth[2]. Writing in *Nature Geoscience*, DeFries and colleagues[3] report that forest loss in the humid tropics is now primarily associated with engagement in international

agricultural markets and the growth of urban populations.

According to a meta-analysis of over 250 studies of tropical deforestation, rural population growth was largely responsible for tropical deforestation in the 1980s and 1990s (ref. 2). This was largely due to government policies to encourage settlement in rural areas, growing demands for forest products, road building and a host of other factors. Today, demands from the wider world are also taking their toll. For example, the global demand for palm oil has led to the expansion of oil-palm plantations in Southeast Asia (Fig. 1), with the concomitant destruction of large tracts of rainforest[4]. And increasing demands for meat and soy products have led to the clearance of Brazilian forests to make way for cattle ranches and soy plantations[5]. However, although these two examples are well understood, the influence of global forces on deforestation in other countries struggling to maintain their tropical forests has been less clear.

DeFries and colleagues[3] examined the influence of demographic, economic and agricultural factors on forest loss in 41 countries in the humid tropics between 2000 and 2005. They used high-resolution satellite data to determine the extent of forest loss. According to their regression analyses, forest loss was positively correlated with urban population growth and engagement in agricultural export markets over this period. In contrast, they found no relationship between rural population growth and deforestation. These emerging relationships between global trade and forest loss can be considered as planetary-scale teleconnections[5] — a term adopted by climate scientists to describe distant but related events.

The findings of DeFries and colleagues indicate that tropical regions have undergone a profound shift in the forces that drive deforestation[3]. Tropical countries may be grouped together in new and unexpected ways, regardless of geographical location. For example, Cambodia and Sierra Leone both have extremely high rates of deforestation, and are best distinguished from other countries by a faster rate of urban population growth.

Although the underlying connection between agricultural trade and forest loss is clear, the mechanistic link between urban population growth and forest loss is less certain. In some regions, increased demand for agricultural products may have encouraged bigger businesses to buy out pioneer farmers, and thereby encouraged the movement of villagers to urban areas. In other settings, growing demands by city dwellers for rural agricultural products may have resulted in the clearance of land for agriculture. However, no matter what the link is, it seems clear that policies aimed at managing rural populations alone will not solve the problem of forest loss in the humid tropics.

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Figure 1 | The aftermath of forest cutting in Borneo. DeFries and colleagues[3] show that urban population growth and international markets are now the main causes of deforestation in the humid tropics.

Of course, there are limits to the policy-relevant conclusions that can be drawn at this stage. Without a mechanistic understanding of the underlying factors responsible for forest loss, it is difficult to say whether a consistent set of causal mechanisms holds between variables in different locations. A better understanding of these mechanisms might allow some nations to establish policies that facilitate urban population growth while keeping forest loss under control. And the passage of time will undoubtedly change the relative importance of demographic variables, which in turn might affect the strength or nature of their relationship with forest loss.

DeFries and colleagues[3] reveal that rural forces no longer dominate deforestation in the tropics. Instead, distant demands from cities and other countries now seem to be the main causes of forest loss. Whether the growth of urban areas and international markets will continue to exacerbate deforestation depends, in part, on the success of a recently approved United Nations programme — Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD) — designed to reduce forest loss and minimize greenhouse-gas emissions by providing developing countries with a financial incentive to maintain their forests[1]. If successful, this programme could overpower today's market forces and urban pressures, and secure a future for the world's tropical forests. ❐

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Correction

In the Editorial 'Earthquakes off Sumatra' (*Nature Geosci.* **3,** 69; 2010), the word 'immanent' in the standfirst should have been 'imminent'. This error was corrected online in the HTML and PDF versions of the text on 7 February 2010.