clusters whose phones have a different operating system. As more and more users start using similar phones and operating systems, the size of these clusters will increase. Percolation theory predicts that once the market share of any operating system reaches a critical threshold, the system undergoes a phase transition and most of the isolated clusters will merge into a single large cluster containing a substantial fraction of mobile phone users. At that point, an MMS virus will be able to instantaneously reach most mobile phone users, and consequently, we'll become seriously concerned about mobile phone viruses. Wang *et al*. also show that this transition point can be accurately predicted by percolation theory (*7*). This transition also explains the relative absence of MMS mobile phone virus outbreaks: Currently, we are below the critical threshold, as smartphones still have a small market share, which is further fragmented by the large number of different operating systems competing in the market.

Yet, consolidation of the mobile phone industry is unavoidable, which means that the phase-transition threshold will be inevitably reached in the near future. Exactly when that happens depends less on network science than on market forces, i.e., the rate at which individuals switch to smartphones. However, some estimates indicate that within 2 to 3 years, there will be more smartphones than desktop computers. Thus, now is the time to start preparing the theoretical knowledge and tools to deal with this expected major threat to mobile communications.

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AGRICULTURE

The Rubber Juggernaut

The demise of swidden cultivation in Southeast Asia may have devastating environmental consequences.

Alan D. Ziegler,[1] Jefferson M. Fox,[2] Jianchu Xu[3]

Rubber plantations are expanding rapidly throughout montane mainland Southeast Asia (*1*–*3*). More than 500,000 ha may have been converted already in the uplands of China, Laos, Thailand, Vietnam, Cambodia, and Myanmar (see the figure, panel A). By 2050, the area of land dedicated to rubber and other diversified farming systems could more than double or triple, largely by replacing lands now occupied by evergreen broadleaf trees and swidden-related secondary vegetation (*2*). What are the environmental consequences of this conversion of vast landscapes to rubber?

Swidden versus rubber. (**A**) Montane mainland Southeast Asia (green shaded areas) is defined here as the lands between 300 and 3000 m above sea level. (**B**) Most swidden fields and fallows on slopes near villages and roads in this area in Xishuangbanna have been converted to terraced rubber stands.

The conversion of both primary and secondary forests to rubber threatens biodiversity and may result in reduced total carbon biomass (*3*–*5*). Negative hydrological consequences are also of concern—for example, in the Xishuangbanna prefecture of Yunnan province, China—but current data are too sparse to quantify the extent of the impacts (*3*, *6*). The effect of conversion to rubber on catchment or regional hydrology depends, in part, on the water use of rubber versus that of the original displaced vegetation. Another factor is the degree to which rainwater infiltration is reduced when terraces are constructed on sloping lands (see the figure, panel B). Unfortunately, a recent investigation into this issue in Xishuangbanna was terminated by regional authorities before sufficient data were collected (*6*, *7*).

The rapid emergence of rubber is the hallmark of a larger land-cover transition that has been sweeping through montane mainland Southeast Asia in recent decades: the demise of swidden cultivation (also referred to as shifting or slash-and-burn cultivation) (*8*). Much of the upland areas that have been converted to rubber in the region are historically associated with swidden cultivation. Clinging to the perception that swidden cultivation is a destructive system that leads only to forest loss and degradation, governments in Southeast Asia have tried to control or terminate it through bans, declaration of forest reserves, forced resettlement, monetary incentives, and crop substitution programs (*9*, *10*). The uncontrolled expansion of rubber in China was encouraged in part because it was seen as a favorable alternative to swiddening. Policies such as the Sloping Land Conversion Program supported the planting of rubber, because it counts as reforestation. Yet such policies have not always improved environmental conditions. In the case of rubber, homogeneous monocultures with myriad negative environmental consequences have emerged. This situation is not new or isolated. The permanent loss of forest cover through agrarian conversion to oil palm in insular Southeast Asia provides a parallel (*11*, *12*).

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In retrospect, it has become clear that the environmental impacts of traditional swiddening were inconsequential until mountain populations increased, cropping periods lengthened, fallow periods became shorter, and the cultivation of opium as a cash crop proliferated after the Second World War. Recent intensification of permanent agriculture has had numerous negative environmental consequences: Erosion has accelerated and stream sediment loads have increased where repetitive cultivation is performed on steep slopes without appropriate conservation methods; permanent conversion of hill slopes and road building have increased the risk of landslides; irrigation of cash crops in the dry season has desiccated streams; and use of pesticides and fertilizers to sustain commercial agriculture has reduced water quality (*13*–*15*).

The unrestricted expansion of rubber in montane mainland Southeast Asia could have devastating environmental effects. A reliable assessment of the hydrological threat requires new data, but time is too short to wait for results from future catchment monitoring programs aimed at quantifying changes in streamflow variables caused by rapid land-cover conversion to rubber. Therefore, studies of rubber evapotranspiration and water use, such as those currently being conducted in Thailand, Cambodia, and Laos, are becoming increasingly important. A substantial increase in natural reserve areas could help to reduce the threats to biodiversity and carbon stocks. Another possible strategy involves paying upland farmers to preserve forest resources. A more realistic approach may be to promote diversified agroforestry systems in which cash crops such as rubber and oil palm play important roles, but are not planted as monocultures.

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GEOPHYSICS

Deep Tremors and Slow Quakes

Detection and monitoring of slow earthquakes may provide a better understanding of ordinary earthquakes.

Gregory C. Beroza[1] and Satoshi Ide[2]

The past decade has witnessed the discovery of a family of unusual earthquakes in what might be termed the infrared part of the seismic spectrum. They are characterized by weak, if any, wave excitation at high frequencies because they happen more slowly than do ordinary, fast earthquakes. The expectation is that these slow earthquakes may provide a better understanding of regular earthquakes, but we are still in the early stages of understanding them.

Slow earthquakes go by a variety of names depending on their magnitude and duration: low-frequency earthquakes with durations of <1 s (*1*), very-low-frequency earthquakes lasting about 20 s (*2*), and slow-slip events that continue for days to months (*3*). Slow earthquakes are frequently accompanied by deep tremor (*4*), which itself appears to be a swarm of low-frequency earthquakes (*5*). To the extent that we have been able to discern their mechanism, slow earthquakes occur as shear slip events of tectonic plates, just like ordinary earthquakes (*2*, *3*, *6*). Although slow earthquakes are located on the same faults that host ordinary, fast earthquakes, they differ in several important respects. They grow steadily, rather than explosively, with time (*7*), and their stress drops are low (*8*).

We'd like to know what relation slow earthquakes have with ordinary earthquakes. Their location on the deep extension of major faults means that they will increase the shear stress on the dangerous shallower stretches of these faults (see the figure). It is therefore important to know whether slow earthquakes cause an increase in the likelihood of an adjacent large earthquake. Slow slip has triggered small nearby earthquakes in several instances (*9*, *10*). However, there have been many well-documented episodes of slow slip in Cascadia, Japan, Mexico, Alaska, and Costa Rica, none of which have been accompanied by a large earthquake. Strong triggering of tremor by lunar tides indicates that tremor can be sensitive to small variations in stress. It is reasonable, then, to speculate that tremor behavior might vary along with variations in stress during the seismic cycle between large earthquakes in subduction zones. Slow slip might even play a role in a slow nucleation process leading to a large earthquake, but that notion remains conjectural.

Tremor can be triggered by waves from distant earthquakes. Most areas that are known to experience tremor in California are of this type (*11*). One location south of Parkfield also has tremor that occurs spontaneously, without being set off by seismic waves, but what about the areas of triggered tremor? Triggered tremor appears to have much in common with spontaneous tremor, but the relation to slow slip is not clear. Does triggered tremor, like spontaneous tremor, occur by shear slip on the deep extension of faults, or is some other mechanism involved? Finding better locations for triggered tremor will be an important first step in addressing this question. Location of tremors near Cholame place them on the deep extension of the San Andreas Fault (*12*).

We would like to understand the distribution and characteristics of tremor and slow earthquakes more generally. In a few areas, such as Japan and western North America, monitoring can detect tremor and slow slip, but in most areas of the world, seismic stations are too widely separated to detect it. Does tremor occur only in tectonically active areas? Even where tremor and slow slip are known to occur, there are mysteries in its distribution. Slow slip is colocated with tremor in Cascadia (*13*) and Japan (*14*), but the overlap may only be partial in Mexico (*15*), and no tremor at all is observed during slow slip in New Zealand (*16*). Spontaneous tremor is seen under part of the San Andreas Fault but not in other subduction zones. Triggered

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