of tumour-intrinsic chemokine molecules — might also be involved[7,12].

Local cues from the host tissue could have a role, too, because bowel metastases exhibited an increase in interactions between tumour cells and immune cells — unlike those at adipose-tissue sites, which showed a reduction in tumour–immune cell cross-talk compared with that at the primary site. Notably, intraperitoneal sites of FBI tumours had high levels of expression of TGF-β, a protein that drives immune suppression and T-cell exclusion. Finally, immunosuppressive subsets of immune cells, such as regulatory T cells, suppressive natural killer cells and myeloid cells, were detected in the primary as well as in the secondary sites. Thus, the anatomical site itself could impose distinct pressures that drive and shape specific states of malignant cells.

Although not addressed in this study, epigenetic regulation might be crucial for the acquisition of these shifts in tumour-cell characteristics as the cancer spreads. Simultaneous investigation of various aspects of tumour cells using genomic, epigenomic and transcriptomic analysis will be essential for understanding how such tumour-cell plasticity sculpts the TME in HGSOC.

Vázquez-García and colleagues' work sets the stage for further discoveries and therapeutic development. Clinical trials of immunotherapy for HGSOC, which have so far been performed without using a biomarker strategy to identify individuals who are most likely to respond to therapy, have yielded disappointing results. The authors' findings confirm that people with HRD tumours would be more likely to benefit from an immunotherapy called immune-checkpoint blockade than would those with non-HRD tumours. However, future mechanistic and biomarker-based investigations in this area should consider the complexity of the metastatic process. Combinatorial immunotherapy designs that include more than one type of immunotherapy should take Vázquez-García and colleagues' findings into account, and could investigate TGF-β blockade as a possible strategy for the treatment of FBI tumours. Finally, this work reminds us of the complex nature of HGSOC, and highlights the urgent and still-unmet need for early and curative immunotherapy interventions.

Denarda Dangaj Laniti and **George Coukos** are at the Ludwig Institute for Cancer Research, Lausanne Branch, and Department of Oncology, Lausanne University Hospital and University of Lausanne, Agora Cancer Research Center, Lausanne 1011, Switzerland.
e-mails: denarda.dangaj@chuv.ch; george.coukos@chuv.ch

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Ecology

An energetic look at the life in logged forests

Pieter A. Zuidema & Joeri A. Zwerts

What are the ecological consequences of logging in a tropical forest? A detailed assessment of vegetation growth, bird and mammal numbers, and energy flows in logged and unlogged forests offers some surprising findings. **See p.707**

Hearing the terms tropical forest and logging commonly evokes images of deforestation. Yet most tropical timber is produced by felling only a limited number of trees in a piece of forest, leaving the structure of the forest mostly intact. As long as they are managed well, logged tropical forests also retain most of their species of plants and animals[1]. These forests represent more than one-quarter of all tropical forests worldwide[2] — an area twice the size of Mexico — so they can make an important contribution to nature conservation. Despite this, logged tropical forests are often regarded as being degraded and in need of recovery. On page 707, Malhi *et al.*[3] provide a very different view of these ecosystems. Gathering an impressive number of field observations, the authors reveal that the logged forests they studied harboured more animal species and were ecologically more 'energetic' than were the unlogged forests.

Malhi and colleagues put a huge amount of work into calculating the number of individuals for 144 bird species and 104 mammalian species. They did this in adjacent areas of undisturbed and logged forest in Malaysian Borneo. At 882 locations, the authors installed camera traps — devices that automatically take pictures when animals pass by. In addition, Malhi and colleagues captured small mammals at 1,488 positions; installed bat traps at 336 sites; and counted birds at 356 locations.

The authors then analysed the many thousands of animal sightings to estimate the abundance and diversity of the creatures. Such analyses were supported by progress over the past few years in computational methods for handling wildlife-observation data[4]. Unexpectedly, the team found that the diversity (Fig. 1) and summed weight of birds and mammals was higher in a logged forest than in an unlogged one. This is probably because environmental

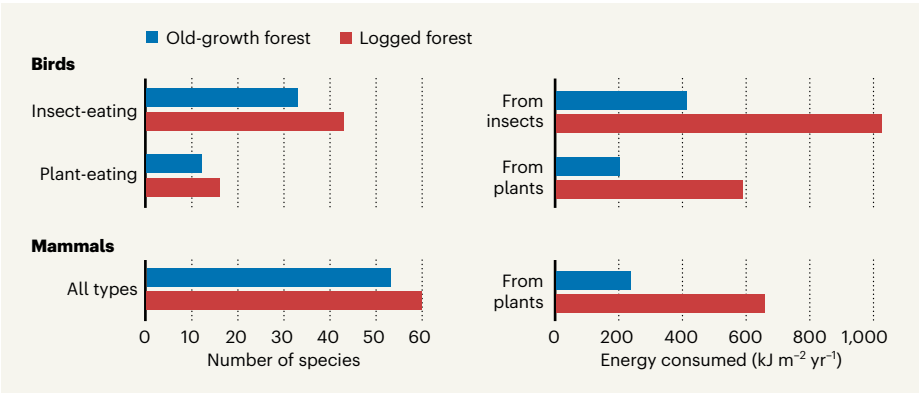

Figure 1 | The effects of logging on birds and mammals in tropical forests. Malhi *et al.*[3] compared logged and unlogged old-growth tropical forest in Malaysia. Surprisingly, the logged sites had a greater number of species than the unlogged sites. For example, logged forests had more species of bird that eat insects or that eat plant material such as fruit and nectar than did the unlogged forests. The authors estimated energy flows through food consumption, and found higher values for logged forests than for unlogged ones. Perhaps logging opens up extra environmental niches that help to boost the forest ecosystem.

conditions are more varied in logged forests, where felled trees leave gaps in the tree canopy that attract other types of animal.

As a next step, the authors calculated energy flows in the ecosystem. They first quantified the total production of energy by plants in the system — namely, the amount of sugars produced by photosynthesis minus the amount needed by the plants for essential respiration processes. This value, known as the net primary productivity, was slightly higher in the logged than in the unlogged forest.

Next, the authors quantified who eats whom in the ecosystem to reconstruct pathways of consumption, from leaves to predators. A remarkable finding was that logging doubled the share of net primary productivity that is consumed by birds and mammals. Birds and mammals consumed more plant material in logged than unlogged forest (Fig. 1). These shifts probably occurred because leaves are more accessible and less chewy after logging. What happens is that gaps in the canopy are filled with large herbs and fast-growing trees that take advantage of the increased sunlight available on the forest floor. These plants typically have highly palatable leaves because they invest all the energy available in them into capturing light and aiding growth, rather than into generating thorns, spines or chemical defence against herbivores.

The most striking shift found in the study was observed for insect-eating birds (Fig. 2). The evidence indicates that insects seem to thrive in logged forests, enabling an increase in the mass and diversity of animals at higher levels of the food chain. Insect-eating birds are high up in this chain: almost half of plant productivity is needed to sustain them. They therefore have a large ecological footprint, as do humans through consuming meat. Yet these birds might also fulfil other key functions, by reducing pest pressure that thereby enables the forest to regrow.

Animal observations from the authors' photographs and sightings provide a wealth of information. But such data usually do not show what and how much animals eat. This is a limitation for an ecosystem-energetics study. The team therefore used available information on the food intake of all observed animal species to estimate the total intake per animal group.

The downside of this workaround is that it does not account for possible shifts in diet as a result of changes in logged forests. For instance, the arrival of fast-growing trees with highly palatable leaves might change the consumption patterns of leaf-eating insects and of mammals. Lacking information on dietary shifts, the authors relied on a robustness test in which they artificially varied consumption patterns. They found that this had little impact on the main outcomes, which is reassuring.

Will the results from this study apply to other logged tropical forests? This is hard to tell, but we can identify some factors that might be relevant. The most crucial of these is hunting. Logging operations require construction of roads and trails. This infrastructure can be inviting for hunters, so logged forests that are poorly managed often turn into half-empty forests — seemingly intact ecosystems devoid of large mammals[5]. Hunting pressures in this study were very low, implying that the results might not apply to many logged forests where hunting pressures are higher.

A second factor to consider is the intensity of logging. The high volume of trees felled in the studied forest and elsewhere in Asia probably results in a greater increase in leaf palatability than would be the case in tropical forests in the Americas and Africa, where logging intensity is much lower[6].

Finally, the surrounding vegetation has a role, too. If logged forests are bordered by agricultural fields or plantations, animal densities might be low even without hunting. In such isolated forests, we would expect a smaller increase in energy flow after logging. Comparative research will be needed to evaluate how these and other factors might modify the shifts in ecosystem energetics that are driven by logging. Thus, the study by Malhi and colleagues could mark the start of a new field — investigations of ecosystem energetics in human-modified forests.

Malhi *et al.* convincingly portray logged tropical forests as fully functional and highly diverse ecosystems. Given their vast extent, logged forests have a crucial role in conserving tropical biodiversity and helping to mitigate climate change. This role is in addition to that of strictly protected forests, where species threatened by disturbance can survive.

Logged forests' conservation potential is hindered by an abundant illegal timber trade, high hunting pressures and a scarcity of forest-management plans. Organizations such as the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC) endorse the management of only a small proportion of forests. We urge policymakers and conservation organizations to put more energy into ensuring that responsible management of logged tropical forests becomes the norm, rather than the exception.

MAREK STEFUNKO/AAMY

Figure 2 | The greater coucal (*Centropus sinensis*), in Malaysian Borneo. This bird, one of the species studied by Malhi *et al.*[3], was found to consume more energy in logged than in unlogged forests.

Pieter A. Zuidema is in the Forest Ecology and Forest Management group, Wageningen University & Research, 6700 AA Wageningen, the Netherlands. **Joeri A. Zwerts** is in the Ecology & Biodiversity group, Utrecht University, 3584 CH Utrecht, the Netherlands.
e-mail: pieter.zuidema@wur.nl

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