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Figure 1 | A monoculture of oil palm (*Elaeis guineensis*) growing beside a forested area. Zemp *et al.*[3] examined the effect on crop yield and biodiversity when an oil-palm plantation is interspersed with areas of native trees termed tree islands.

Ecology

Tree islands bring benefits for oil-palm plantations

Robert Nasi

The cultivation of oil palm is here to stay. However, a five-year study indicates that creating islands of native trees within oil-palm monocultures increases biodiversity and ecosystem functioning without notably lowering crop yields. **See p.316**

Oil palm (*Elaeis guineensis*) is ubiquitous. Used in nearly every commercial sector[1], it is on the label of thousands of food and cosmetics products and is also found in detergents, animal feed and biofuel. The fruits of oil palm are harvested across 20 million hectares in 49 countries[2]. But although it is an efficient crop, supplying 40% of the global market for vegetable oil on less than 6% of the land used to produce all other plant oils (see go.nature.com/3pfkbc1), the expansion of oil-palm cultivation in the form of monoculture plantations has led to widespread deforestation and biodiversity loss.

Zemp *et al.*[3] report on page 316 that dotting oil-palm monocultures with what are termed tree islands – generated using a form of agroforestry in which small areas of native trees are planted or allowed to regenerate naturally – can be a practical way to restore biodiversity and ecological functioning in commercial oil-palm plantations without significantly affecting crop yields.

Using a robust experimental design and presenting a variety of measures and analyses, the authors report convincing findings from a large-scale, five-year experiment to investigate ecosystem restoration in a 140-hectare oil-palm landscape enriched with 52 tree islands. The study assessed biodiversity and ecosystem functioning associated with tree islands of varying sizes (ranging from 25 square metres to 1,600 square metres) and with different numbers of native trees per island, from zero (natural regeneration only) to one, two, three or six planted species. The authors examined 10 indicators of above- and below-ground biodiversity and 19 indicators of ecosystem functioning, such as pollination, soil quality and regulation of water and climate.

The results indicate that, compared with conventionally managed oil-palm monoculture lacking tree islands, the oil-palm sites with tree islands had a higher diversity of bird, tree and seed-providing species, as well as greater diversity among a variety of groups of species. The sites with tree islands also had better water infiltration and soil fertility, and showed improved signs of other ecological function. Larger tree islands yielded greater restoration benefits, and the authors suggest that these islands could act as 'keystone' structures that might help to establish more-diverse ecological communities. Importantly, these gains were achieved without compromising the overall agricultural productivity.

The findings are timely and serve to strengthen a growing body of work examining the benefits of implementing agroforestry practices in oil palm[4,5] and in other monoculture crops, such as coffee, cocoa and rice. The results also help to fill knowledge gaps that will support conservation efforts during the United Nations Decade on Ecosystem Restoration, which began in 2021 (see go.nature.com/3mbj9a8).

Of course, as for many such experiments, this is just the beginning. Trees and palms are long-lived, after all. Before a convincing argument can be made for the widespread adoption of the intervention – and before the approach should be considered for incorporation into certification standards, such as the Roundtable on Sustainable Palm Oil – several questions, including the following, need to be answered. What area and spatial distribution of tree islands would be needed to maximize the positive environmental effects while sustaining oil-palm yields? Should the establishment of such islands be recommended for all industrial palm estates? How can connectivity between habitats be optimized (for example, by using tree islands as 'stepping stones' for species, or by protecting vegetation along rivers and streams)?

What sorts of agroforestry practice might be recommended for the strikingly different contexts of large, homogeneous industrial oil-palm plantations compared with smallholder plots, which tend to be part of mosaic landscapes? Indonesia and Malaysia, which supply more than 80% of global oil-palm demands (see go.nature.com/42hhyjr), are dominated by sprawling industrial-scale estates[2]. However, research in Indonesia shows that, by 2030, the total area of smallholder oil-palm plots is expected to exceed 60% of the total national acreage[6].

Experiments in Brazil[7] indicate that, for smallholders, growing oil palm in a complex agroforestry system can increase oil productivity per palm and enable a more diversified income stream through the sale of other products (such as fruits, timber or cassava); such an approach might also avoid the need for fertilizer or pesticides. Zemp and colleagues suggest that smallholders adopting the use of tree islands would also benefit from improved ecosystem benefits (ecosystem services), lower susceptibility to disturbance and the diversification of risk. However, because it is unlikely that agroforestry practices will gain traction with large industrial producers, the tree-island option (either by retaining some vegetation when clearing the land or establishing tree islands after the oil-palm crop is planted) seems more adapted for adoption in industrial plantations than are agroforestry approaches.

What will happen as the trees continue to grow? On the basis of this study and previous measurements by members of the same team[8], one might expect an eventual reduction in productivity per palm in and around the tree islands as other species grow and compete for resources with oil palms (Fig. 1). How will this affect production on the landscape scale? What will happen after 25 years, when the palms need to be cut and replanted?

Finally, what are the economics of these different models of oil-palm management? That aspect of research is currently missing, because published papers have focused chiefly on demonstrating that agroforestry interventions do not affect productivity at the level of a plot (termed stand level).

The reality is that, despite its growing environmental footprint, oil-palm cultivation is not going away. With an estimated 2022 global market value of US$53 billion (see go.nature.com/41hj7xe), it is a key contributor to national economies and local livelihoods. Despite some progress in developing cultured or synthetic oil, the crop is simply too lucrative[9] for industrial developers and rural communities to pass it up. Agroforestry-based approaches are not a substitute for protecting remaining forests, yet this work by Zemp and colleagues, as well as other studies, demonstrates that the use of tree islands could go a long way to helping restore biodiversity and ecosystem health in oil-palm landscapes.

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Computer science

AI learns to write sorting software on its own

Armando Solar-Lezama

Deep reinforcement learning has been used to improve computer code by treating the task as a game – with no special knowledge needed on the part of the player. The result has already worked its way into countless programs. **See p.257**

For decades, the computing industry relied on Moore's law: as transistors became ever smaller, the number that could be crammed onto a computer chip seemed to double every two years, enabling a similar leap in computing power. But Moore's law has a natural limit, so software optimization has become just as crucial as miniaturization. On page 257, Mankowitz *et al.*[1] reveal a key role for deep learning in this process, by showing that code generated by artificial intelligence (AI) can improve the efficiency with which the C++ programming language sorts items in a list. Although seemingly mundane, this task is needed in computer programs the world over, and the AI version is now baked into a widely used implementation of the C++ library. Perhaps even more remarkably, the AI system can improve the code without any previous knowledge of the problem itself.

To understand the implications of Mankowitz and colleagues' result, it is useful to first understand the way in which programs are translated into instructions that tell a machine how to flip its ones and zeroes. For a programming language such as C++, a program called a compiler takes source code and converts it into a set of 'assembly' instructions that are, in turn, translated into machine-level code.

The conventional approach[2] to improving the performance of a piece of source code was to apply a series of transformations that were guaranteed to preserve the behaviour of the program while changing performance characteristics such as speed and memory usage. Modern compilers can improve performance substantially by applying such optimizations, but the benefits are constrained by the limited set of transformation rules available to them, and by the difficulty of predicting whether a given change will improve performance.

In the late 1990s and early 2000s, there was a push to do better by searching through different sequences of transformations to find