News & views

Figure 1 | A bean field bordering a rainforest reserve near Sorriso, Brazil.

Conservation

A recipe to reverse the loss of nature

Brett A. Bryan & Carla L. Archibald

How can the decline in global biodiversity be reversed, given the need to supply food? Computer modelling provides a way to assess the effectiveness of combining various conservation and food-system interventions to tackle this issue. **See p.551**

Nature is in trouble, and its plight will probably become even more precarious unless we do something about it[1]. On page 551, Leclère *et al.*[2] quantify what might be needed to reverse this deeply worrying path while also feeding people's increasingly voracious appetites. The authors' answer is to team ambitious conservation measures with food-system transformation in the hope of reversing the trend of global terrestrial biodiversity loss.

By nature, we mean the diversity of life that has evolved over billions of years to exist in dynamic balance with Earth's biophysical environment and the ecosystems present. Nature contributes to human well-being in many ways, and the services it provides, such as carbon sequestration by plants or pollination by insects, could impose a vast cost if lost[3]. Although the slow and long-term decline of Earth's biodiversity[4] is often overshadowed by climate change, and more recently by the COVID-19 pandemic, the loss of biodiversity is no less of a risk than those posed by the other challenges. Many would argue that the effect of biodiversity losses could surpass the combined impacts of climate change and COVID-19.

More and more, the realization is growing that, as a planet, we are what we eat. Human demand for food is accelerating with the ever-increasing global population (projected to approach 10 billion by 2050), and each successive generation is wealthier and consumes more resource-intensive diets than did the previous one[5]. Trying to balance this rapidly rising demand against the limited amount of land available for crops and pasture sets agriculture and nature (Fig. 1) on a collision course[6]. As Leclère and colleagues show, a bold and integrated strategy is required immediately to turn this around.

Taking a long view out to the year 2100, Leclère *et al.* present a global modelling study assessing the ability of ambitious conservation and food-system intervention scenarios to reverse the decline, or, as they call it, "bending the curve", of biodiversity losses resulting from changes in agricultural land use and management. Projections of future land use and biodiversity are uncertain, and when these models are combined, this uncertainty is compounded. One of the great innovations of Leclère and colleagues' work is in embracing this uncertainty by combining an ensemble of four global land-use models and eight global biodiversity models and measuring the performance of future land-use scenarios in terms of higher-level model-independent metrics such as the amount of biodiversity loss avoided.

Importantly, the study also included a baseline (termed BASE) scenario – the world expected without interventions – and Leclère *et al.* used this to gauge the effectiveness of the intervention scenarios. Although it is not a focus of the paper, it's worth pausing to ponder the sobering picture painted by this business-as-usual future largely bereft of birdsong and insect chirp.

Choosing to act now can make a difference to nature's plight. Most (61%) of the model combinations run by the authors indicated that implementing ambitious conservation actions led to a positive uptick in the biodiversity curve by 2050. Such conservation actions included: extending the global conservation network by establishing protected nature reserves; restoring degraded land; and basing future land-use decisions on comprehensive landscape-level conservation planning. This comprehensive conservation strategy avoids more than half (an average of 58%) of the biodiversity losses expected if nothing is done, but also leads to a hike in food prices.

When conservation actions were teamed with a range of equally ambitious food-system interventions, the prognosis for global biodiversity in the model was improved further. Including both supply- and demand-side measures, these approaches included boosting agricultural yields, having an increasingly globalized food trade, reducing food waste by half, and the global adoption of healthy diets by halving meat consumption. These combined measures of conservation and food-systems actions avoided more than two-thirds of future biodiversity losses, with the integrated action portfolio (combining all actions) avoiding an average of 90% of future biodiversity losses. Almost all models predicted a biodiversity about-face by mid-century. These food-system measures also avoided adverse outcomes for food affordability.

Leclère and colleagues' work complements the current global climate-change scenario framework (tools for future planning by governments and others, including scenarios called shared socio-economic pathways, which integrate future socio-economic projections with greenhouse-gas emissions), and represents the most comprehensive incorporation of biodiversity into this scenario framing[7] so far. However, a major limitation of the present study is that it does not consider the potential impact of climate change on biodiversity. This raises an internal inconsistency because, on the one hand, the baseline scenario considers land-use, social and economic changes under approximately 4 °C of global heating by 2100 (ref. 8), yet, on the other hand, it does not consider the profound effect of warming on plant and animal populations and the ecosystems they comprise[9]. Also absent from the models were other threats to biodiversity, including harvesting, hunting and invasive species[10]. Although Leclère and colleagues recognized these limitations and assigned them a high priority for future research, unfortunately for us all, omitting these key threats probably means that the authors' estimates of biodiversity's plight and the effectiveness of integrated global conservation and food-system action are overly optimistic. To truly bend the curve, Leclère and colleagues' integrated portfolio will need to be substantially expanded to address the full range of threats to biodiversity.

Although the models say that a better future is possible, is the combination of the multiple ambitious conservation and food-system interventions considered by Leclère *et al.* a realistic possibility? Achieving each one of the conservation and food-system actions would require a monumental coordinated effort from all nations. And even if the global community were to get its act together in prioritizing conservation and food-system transformation, would such efforts come in time and be enough to save our planet's natural legacy? We certainly hope so.

Brett A. Bryan and **Carla L. Archibald** are at the Centre for Integrative Ecology, Deakin University, Melbourne, Victoria 3125, Australia.
e-mail: b.bryan@deakin.edu.au

1. Díaz, S. *et al. Science* **366**, eaax3100 (2019).
2. Leclère, D. *et al. Nature* **585**, 551–556 (2020).
3. Costanza, R. *et al. Glob. Environ. Change Hum. Policy Dimens.* **26**, 152–158 (2014).
4. Butchart, S. H. M. *et al. Science* **328**, 1164–1168 (2010).
5. Springmann, M. *et al. Nature* **562**, 519–525 (2018).
6. Montesino Pouzols, F. *et al. Nature* **516**, 383–386 (2014).
7. Kok, M. T. J. *et al. Biol. Conserv.* **221**, 137–150 (2018).
8. Leclère, D. *et al. Towards Pathways Bending the Curve of Terrestrial Biodiversity Trends Within the 21st Century* https://doi.org/10.22022/ESM/04-2018.15241 (Int. Inst. Appl. Syst. Analysis, 2018).
9. Warren, R., Price, J., Graham, E., Forstenhaeusler, N. & VanDerWal, J. *Science* **360**, 791–795 (2018).
10. Driscoll, D. A. *et al. Nature Ecol. Evol.* **2**, 775–781 (2018).

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Biotechnology

Yeast learns a sorceress's secret

José Montaño López & José L. Avalos

Yeast has been engineered to convert simple sugars and amino acids into drugs that inhibit a neurotransmitter molecule. The work marks a step towards making the production of these drugs more reliable and sustainable. **See p.614**

In Homer's *Odyssey*, the sorceress Circe slipped Odysseus' companions a poison to induce amnesia and hallucinations. Scientists have speculated[1] that Circe's concoction contained the plant jimsonweed (*Datura stramonium*), which is rich in drugs called tropane alkaloids that are used to treat asthma, influenza symptoms and pain, and that can induce hallucinogenic and other psychotropic effects. Tropane alkaloids, like most other plant natural products, are still typically extracted from natural sources, but this approach has many pitfalls. For instance, vulnerability to weather and market fluctuations can limit access for both patients and researchers, and extraction can be environmentally harmful[2,3]. In addition, plants typically contain very low levels of these active ingredients. On page 614, Srinivasan and Smolke[4] report an alternative way to make tropane alkaloids that could relieve these limitations – using engineered strains of the baker's yeast *Saccharomyces cerevisiae*.

Plants produce a variety of specialized compounds that help them to adapt and survive. Biosynthesis of these natural products often involves lengthy metabolic pathways that have complex dynamics and regulation. One of the major achievements in the field of metabolic engineering has been the development of microorganisms that can produce plant natural products[5–7]. However, the approach is far from routine because the enzymes involved in biosynthesis are often unknown, might be inactive in microbial hosts, and can be segregated across different plant subcellular compartments, cells or tissues.

Srinivasan and Smolke have overcome these challenges to produce a strain of *S. cerevisiae* that converts simple sugars and amino acids into two tropane alkaloids, hyoscyamine and scopolamine. These tropane alkaloids block the action of the neurotransmitter molecule acetylcholine[8]. They are used to treat nausea, gastrointestinal problems, excessive bodily secretions and neuromuscular disorders, including Parkinson's disease[9,10].

Srinivasan and Smolke genetically engineered their yeast strain to overexpress 26 genes from different kingdoms of life. Together, these genes encode several metabolic enzymes and transporter proteins. Key to the authors' achievement is the fact that they separated the enzymes and transporters into six subcellular locations – the cytosolic fluid, four organelles (the mitochondrion, peroxisome,vacuole and endoplasmic reticulum),