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Growing a forest with biodiversity, climate and people in mind

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Forest plantations can be much more than wood 'factories'. They can be havens of biodiversity, 'banks' that lock carbon away from the atmosphere, not to mention beautiful places for recreation. The good news is that, not only is it possible to regrow forests so that they work for nature, but that this goal can be better achieved with the help of science.

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The emergence of carbon markets over recent years has given developed countries (including Europe, USA, Japan and Australia) – as well as family landowners, local communities and forest industries in developing countries supported by the UN-REDD+ program – opportunities to regrow forests that sequester carbon.

For many early adopters, plantations of fast-growing, single-species trees – 'monocultures' – are a good way to quickly achieve carbon sequestration. This approach is based on the idea of 'land sparing', which refers to the sparing of land for nature from agricultural production. This idea has dominated land-management thinking in recent decades.

Land sparing involves the practice of creating different forest parcels, each with a single objective that needs to be optimised: one parcel for intensive timber production; one for carbon planting; one for food, firewood or medicine; one for biodiversity conservation; and so on.

The approach has helped protect many forest lands and associated biodiversity during recent rapid industrial transitions in many countries. While the focus of this approach is to maximise a single objective, other values may be coincidentally but not intentionally produced.

For instance, land sparing has been very successful in countries like Vietnam, where land rehabilitation with acacia plantations has improved soil values, helped reduced logging of native forests and generated a multi-billion-dollar wood, paper and furniture industry that has helped reduce rural poverty.

However, land sparing also has it downsides.

Rows of identical trees mean reduced genetic diversity and potentially reduced resilience – in other words, a singl-species carbon-sequestration plantation could be more readily wiped out by disease than a more biodiverse plantation. Mono-plantings can also discourage the establishment of higher plant diversity in the understorey.

In some situations, single-species plantations can lead to lower carbon levels stored in the soil over the long-term compared with native forest or mixed forest situations. They may also have negative socio-economic impacts for local people whose livelihoods depend on a diversity of ecosystem services (in the form of fresh water, food, shelter, etc).

Finally, preventing human activities in 'spared' forests is not always desirable or practical, given the inextricable links between forests and people that have developed over many millennia.

In short, the situation is complex. Land sparing can achieve dramatic results in terms of economic benefit or rates of carbon sequestration alone. But when forest managers overlook the social and ecological synergies and benefits that more biodiverse multiple-use forests can provide, they may not realise the full potential of afforestation activities.

To share or to spare?

So what can landholders do to regrow forests that mitigate climate change, while conserving biodiversity and producing income?

In a paper recently published in *Global Change Biology*, researchers from CSIRO (including this author) and Queensland University of Technology presented a decision-support model that can help forest stakeholders resolve this dilemma. The new software tool is designed to help them make better decisions on complex issues – for example, when, where and how to share forest lands for different uses, or when to spare forest lands for a single purpose.

Using the model, managers can predict carbon stocks and plant biodiversity in response to different combinations of determining factors – which might include forest management strategy, climate uncertainty, landscape and soil characteristics. So, for example, a user can predict and optimise biodiversity, carbon and harvesting outputs from a forest through combining different planting, thinning, harvesting and weeding regimes.

The model combines the biological detail and species interaction of current ecological models with management decision support more typical of single function forest management models. Thus it captures the best of both worlds and so supports land managers making decisions that straddle the socio-economic and the ecological worlds.

In complex native forests or plantations used as a source of forest products – such as timber, firewood, fruit, seeds/beans, bark, medicinal plants or latex – the model can combine carbon and biodiversity objectives with economic outcomes, revealing the best forest management strategies for optimising all outcomes.

This means it can be used to facilitate resolution of long-term forest-land conflicts between groups having different interests: forest biodiversity conservation, forest carbon sequestration or forest livelihood harvesting.

Credit: Jane Drumsara (CC BY-NC-SA 2.0)

We used the model to simulate regrowth of forests in South-East Queensland, with the objective of maximising long-term carbon sequestration and plant biodiversity through planting and thinning. Our results show that carbon and biodiversity objectives could – but not always – be maximised on shared land, whether for new or existing forests.

We found that the position in the catchment, the climate system and the type of planting and thinning were important in predicting whether land sharing or land sparing would work best to get better biodiversity-carbon outputs.

For researchers, the model may be used as a heuristic tool when species-level biology is not known. However, it cannot replace full knowledge of the biology of species of interest.

Making online access easier

The team of researchers from CSIRO and the University of Queensland are currently testing a fine-tuned version of the model using datasets from 500 Australian forest plots in Queensland. These datasets represent several years' measurements of tree biodiversity, carbon storage and plant functional traits under various planting and thinning regimes.

Our team will also develop an easy-to-use web interface linked to the model for users such as landowners, land managers and NGOs. On entering GPS coordinates of the forest site under investigation – and it could be anywhere in the world – users would be able to determine:

1. soil type (percentages of clay, loam and sand)
2. soil depth
3. topography
4. closest meteorological station, and
5. type of tree species and their relative proportion in that forest.

The next step might involve defining a set of planting, thinning and harvesting strategies (type of species, frequency) that could be applied to that forest.

The user could run the model online to see the expected long-term return from that forest – in term of carbon stocks, biodiversity and (if it's of interest to the user) the livelihood incomes from harvests – and eventually be able to rank available management strategies that would best achieve these outputs.

Dr Jean-Baptiste Pichancourt is an ecologist interested in developing integrated models to help stakeholders logically structure their decisions when managing forests with multiple social, ecological, production and cultural values. Those keen to try the current version of the model can email a request to jean-baptiste.pichancourt@csiro.au

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