LETTERS

Eucalyptus monocultures are often more profitable than species-rich forests.

PHOTO: MINGMAN/ISTOCK

Forest value: More than commercial

Edited by **Jennifer Sills**

IN THEIR RESEARCH Article "Positive biodiversity-productivity relationship predominant in global forests" (14 October, p. 196), J. Liang *et al.* establish a positive relation between forest productivity and commercial value to show the importance of tree species richness for supporting high productivity. They estimate that a drop in the current level of species richness in forests to one species would cost US$166 to $490 billion annually. However, species richness and ecological productivity are poor indicators for commercial value. According to the richness-value assumption, megadiverse tropical forests would provide high commercial value. In fact, the opposite is usually true. Cubbage *et al.* (*1*) showed that species-rich subtropical or tropical native forests are much less profitable than planted monocultures. In these forest types, only 20% of tree species or fewer are commercially valuable, and the harvests may be as low as 0.7 cubic meters per hectare per year (*2*), less than 10% of global average productivity according to Liang *et al.*

Planted forests provide a large part of the commercial value of the world's forests. The area of planted forests expanded from 167 to 278 million ha between 1990 and 2015, contributing 46% of the world's industrial roundwood in 2012 (*3*). The most profitable planted forests are not necessarily species rich (*4*), although forest types with two or more species may compete with monocultures in the temperate zone (*5*). For example, in South America, 88% of planted forests consist of introduced exotic species, usually grown as monocultures. Such forest types show very high economic return (*6*). There is no economic evidence for the loss in commercial value that Liang *et al.* claim.

Postulating a positive relation between tree species richness and commercial value could potentially have adverse environmental consequences. For example, concluding that megadiverse tropical forests have innate commercial value would make it unnecessary to supplement this supposed value with rewards for landowners who preserve their native forests. Landowners might then continue to convert such forests to profitable monocultures such as eucalyptus, which have real commercial value. Species-rich forests indeed have an extremely high conservation and ecosystem service value, but their commercial value is often low.

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Response

PAUL AND KNOKE address the commercial value and profitability of forest biodiversity, which differs fundamentally from the economic value that we outlined in our Research Article. To translate the biophysical productivity gains from increased forest biodiversity into gross economic value, we used two different global estimates of forest value: One estimate calculated the economic value of ecosystem services as a function of standing forest biomass (*1*); the other estimate determined the gross value added to the global forestry sector (*2*). Neither of these estimates directly reflects the commercial value of forests. Our estimates pertain to the sole contribution of tree species diversity, as it exists today, to global forest productivity, from which the economic value accrues. Our analysis—which includes nonmarket values not commonly captured in commercial forestry but excludes the contribution of forest biodiversity to carbon sequestration, wildlife habitat, and aesthetic and cultural values—reflects only a small portion of the true economic value of forest diversity at a global scale.

Our Research Article emphasized that biodiversity begets productivity value in either "unmanaged or extensively managed forests." We did not compare unmanaged forests to planted monocultures. Monoculture profitability of planted forests results mostly from choosing a high-value and often exotic species that may be more commercially profitable in the short term because of lower costs of production, processing, and distribution; higher price per unit sold; and greater productivity associated with the unique traits of that species. We focused purely on biophysical productivity. Because market prices often fail to reflect the nontradable benefits associated with ecosystem services, market profitability is a flawed indicator of the true economic value of standing forests, as it is of most environmental amenities (*3*–*5*). Furthermore, the conversion of species-rich native forests to monoculture plantations of exotic species is quite different from the comparison of forests with current levels of diversity to hypothetical forests of one species; our Research Article used the latter comparison to strictly estimate the contribution of diversity to productivity in native forests. Learning how to simultaneously maximize complexity, resilience, nonmarket values, and profitability is a central challenge for forestry (*6*).

From a policy/management perspective, the positive biodiversity-productivity relationship across the world's forests helps justify rewarding landowners for preserving or enhancing the diversity of their native or planted forests. Establishing the underlying biophysical relationship between species richness and productivity, and translating that into economic

terms, reveals where markets fail to fully capture the true long-term economic value of forests, as opposed to the short-term commercial value, and thus where conservation attention is most needed.

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Iran's science landscape in context

IN HIS IN DEPTH News Story "In Iran, a shady market for papers flourishes" (16 September, p. 1197), R. Stone reports on the sale of plagiarized papers among Iran's scientists. This issue must be interpreted in context; Iran's fledgling science community (*1*) should not be judged as if it is a well-established scientific community in a scientifically advanced country.

The revolutionary Iran came into existence with some 26 universities and 175,000 students in 1979 (*2*), when the country's published papers totaled less than 400 (*3*, *4*). For the first two decades after revolution, Iran's scientists were mainly engaged with establishing the necessary scientific and technological infrastructure. Twenty years after the revolution, the number of papers published by Iranian scientists was still not much more than 1000 (*3*, *4*).

In 2000, when the number of publications began to increase dramatically (*3*, *5*), Iran's scientists and the science policy-makers started to become cautious about the output of the research done by our scientists. In the relatively short time that Iran has increased its published science output, its number of established institutions and students, and every other aspect of science activity, we have not been successful enough in establishing a scientific community with an innate code of ethics ("Creating a culture of ethics in Iran," M. S. Rezaee-Zavareh *et al.*, Letters, 21 October, p. 296). Many of Iran's university faculty are not even aware of what is and is not allowed in the scientific community. The time scale of structural change in the scientific sphere of the country has been too short and its acceleration too high to develop the necessary scientific "soft infrastructure."

It was just 2 years ago that the Ministry of Science, Research, and Technology of Iran asked our universities and research institutes to establish internal committees on science ethics (*6*). There is now a group of university faculty running a website about plagiarism called "Professors Against Plagiarism" (*7*). In the past 2 years, universities have started to

address cases of plagiarism. Investigations are lengthy, and if a faculty member is found guilty, the results could include the termination of his or her contract.

There are likely many more cases of plagiarism within our scientific community, even more than already revealed by articles such as Stone's story. I am confident that the growing scientific community of Iran will establish a strong community with a vibrant discourse and code of ethics to minimize this plagiarism in time (*8*). I urge the international community to help Iran's efforts to establish a healthy scientific community for the sake of the region and the world.

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TECHNICAL COMMENT ABSTRACTS

Comment on "Structural basis of histone H3K27 trimethylation by an active polycomb repressive complex 2"

Ying Zhang, Neil Justin, Jon R. Wilson, Steven J. Gamblin

Jiao and Liu (Research Articles, 16 October 2015, aac4383) reported the crystal structure of the protein complex polycomb repressive complex 2 from *Chaetomium thermophilum*. This landmark structure has brought invaluable insights into the activation mechanism of this essential methyltransferase. However, the analysis of the x-ray data discussed below suggests that the description of oncogenic H3K27M peptide binding to the active site is incorrect.

Full text at http://dx.doi.org/10.1126/science.aaf6236

Response to Comments on "Structural basis of histone H3K27 trimethylation by an active polycomb repressive complex 2"

Lianying Jiao and Xin Liu

Zhang *et al.* suggested that in the crystal structure of a polycomb repressive complex 2 from *Chaetomium thermophilum* (*ct*PRC2), a flexible linker region, but not the H3K27M cancer mutant peptide, better fits the electron density. Based on our new data, we agree with this alternative interpretation and provide the crystal structure of *ct*PRC2 bound to a bona fide H3K27M sequence.

Full text at http://dx.doi.org/10.1126/science.aaj2335

ERRATA

Erratum for the Report "Local modulation of human brain responses by circadian rhythmicity and sleep debt" by V. Muto *et al.*, *Science* **354,** aam5837 (2016). Published online 23 December 2016; 10.1126/science.aam5837

Erratum for the Report "Coordination-induced weakening of ammonia, water, and hydrazine X–H bonds in a molybdenum complex" by M. J. Bezdek *et al.*, *Science* **354,** aal4584 (2016). Published online 9 December 2016; 10.1126/science.aal4584

Forest value: More than commercial—Response

Christopher B. Barrett, Mo Zhou, Peter B. Reich, Thomas W. Crowther and Jing jing Liang (December 22, 2016)

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Editor's Summary

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