Introduction to the special issue

Tropical forests under a changing climate and innovations in tropical forest management

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The Rio + 20 United Nations Conference on Sustainable Development is recently behind us. Certainly the official proceedings were a serious disappointment. The draft document was weak to begin with and even weaker after negotiations concluded. Clearly the world as a whole had failed to address the environmental issues at scale in the twenty years after the Earth Summit. The new agreement is filled with aspirational language and failed to make meaningful commitments on greenhouse gas reduction and stemming biodiversity loss. These latter were left to the actual conventions to address. In the meantime the sustainable development goals proceed to develop with critical elements like population growth unaddressed.

In contrast, the commitments and discussion in the 3000 side events were lively and promising with issues of forests (such as those addressed in the 2010 and 2011 annual conferences of the Yale Chapter of the International Society of Tropical Foresters) prominent. For example, the Consumer Goods Forum (composed of companies with $3.1 trillion annual revenue) committed that their supply chains would be net deforestation free by 2020.

Three months earlier, 3000 scientists participated in the Planet Under Pressure conference to provide scientific input to Rio + 20. The meeting acknowledged the violation of planetary boundaries of CO_2, nitrogen and biodiversity[1] There was widespread recognition that fragmented and compartmentalized approaches to science were woefully insufficient and recommended a new science initiative, dubbed "Future Earth", which will integrate the physical, biological and social sciences – much in the fashion of this collection of papers from the two Yale ISTF meetings.

Science is clearly central to resolving this head-on collision between the future of the planet and its habitability. And forests are very much part of that agenda. The kinds of contributions made in these papers are necessary building blocks. Many of them already show the kind of integration called for by "Future Earth".

As essential as this kind of integrated science is, there is simultaneously a need to scale up in our thinking about science. If we do not, then the very matters we see so well addressed in this collection will fail to be resolved because they will be overwhelmed by other aspects of regional and planetary change.

A case in point was the recent intense debate in the Brazilian Congress about the Forest Code (Codigo Forestal), which unfolded over many months prior to Rio + 20. The issues were many and complex and it is not my intent to engage in that debate. Rather I want to flag the importance of the Amazon as a flywheel of continental climate.

Pioneering work of Brazilian scientist Eneas Salati [2,3] demonstrated about 30 years ago that the Amazon generates about half of its own rainfall. Essentially, moisture enters the Amazon from the tropical Atlantic, falls as rain and then much of it evaporates off the complex surfaces of the forest and transpires through the leaves, returning to the westward bound air mass and producing further rain. When the moisture laden air reaches the high wall of the Andes, most of it falls as rain and creates the Amazon River system, but some of the moisture is deflected and contributes to rain in agricultural areas such as Mato Grosso to further south all the way to Argentina. These findings actually shattered the long held paradigm that vegetation is purely the consequence of climate and has no influence upon it.

It therefore became apparent that at some point deforestation could cause the hydrological cycle to degrade to a point that local climate would be insufficient to maintain rainforest integrity. One study suggests that tipping point would occur at about 40% deforestation [4]. The impact of diminished rainfall was demonstrated by the experimental work of Nepstad et al [5], which also shows clearly that the increased incidence of fires in the Amazon has been affecting the hydrological cycle as well. Subsequently, several years ago Hadley Center modeling of climate change indicated dieback in the southern and eastern Amazon, first at 2.5 degrees and subsequently at 2.0 degrees, though the most recent model run showed no effect at all [6,7].

But what has been the *combined* effect of deforestation, fire and climate change? This was addressed by a million dollar World Bank study with modeling led by Brazil's Carlos Nobre [8]. That study suggested a possible tipping point toward Amazon dieback at about 20% deforestation. That possible tipping point, while of enormous salience to the Forest Code debate (especially with current deforestation at close to 19%), was never central to that discussion as it should have been. In part, this lapse occurred because Carlos Nobre was called to serve as National Secretary for Research and Development Policy in the Ministry of Science, Technology and Innovation in Brasilia before a proper peer-reviewed scientific paper was published based on the World Bank report.

Consequently, there was a lot of irrationality in the arguments to weaken the code. One fallacy was the notion that agricultural productivity cannot increase unless more forest is cut. Brazil's own internationally renowned agricultural research agency EMBRAPA has indicated that cattle production could be doubled with half the land currently in use (i.e., increased by a factor of four with all current rangelands). This finding seems to have been ignored in the way that supply chain regulations will not. But a larger scientific picture -- namely that the Amazon must be managed in an *integrated* manner to maintain that critical hydrological cycle, i.e. the Amazon needs to be managed as a holistic system—was entirely absent.

Similarly, at Rio + 20, the broader scientific aspects seem to have been ignored or relegated to the sidelines. On climate, the debate centered on how to stop at two degrees increase of global temperature rise (and with many talking blithely about three, four, five and even six degree increases), regardless of the fact that the only way to stop at two degrees is for emissions to peak in 2016. And the two degree number appears to be pretty arbitrary, based more on what might be "doable" from a fossil fuel perspective than on the habitability of the planet. From an ecosystem and biodiversity perspective--both essential for human wellbeing-- two degrees is clearly too much. Thus, it is imperative for larger-scale science to build this case and inject it into the international negotiating processes.

In the keynote for the 2010 Yale ISTF conference I addressed the impacts of climate change on biodiversity. The same ten thousand years of relative climatic stability that allowed human civilization to flourish also led all ecosystems to adjust to that stable climate. By now there is abundant evidence of the impacts of climate change on nature all over the world: life cycle modifications, changes in species distribution patterns, impacts of oceanic acidification on shellfish spawning beds.

Already even larger impacts are being observed, prominent among them bleaching events in coral reefs when short periods of warmer water causes the entire ecosystem to collapse. So it is very clear that a two degree world will be one without coral reefs upon which one-twelfth of humanity depends for its livelihood [9,10]. Additionally, there is a tipping point favoring bark beetles in the coniferous forests of North America leading to massive tree mortality. Doubly compounded by dryer weather, the result is that massive forest fires have now become a regular part of summertime news.

The last time the world was two degrees warmer the seas were four to six meters higher [11]: that doesn't happen immediately but the impacts for many islands states -- and even the location of the Earth Summit and Rio + 20 itself -- are clear.

The Yale ISTF conference papers are, of course, focused on tropical forests. They include not only the impact of climate change but also papers on ways forests can be managed, provide local benefits and economic return, and at the same time contribute to a better function of the biosphere and the planet. They are building blocks of a vital larger picture.

It is now quite clear to a small but growing number that the planet needs to be managed as the biophysical system that it is, and that biology has a great deal to contribute to a better future for life on Earth (and including this primate unintentionally run amok). A fifty year effort in ecosystem restoration at a planetary scale can remove 50 parts per million of CO2 from the atmosphere just by changing the way we manage forests, grasslands and agro-ecosystems. There is a significant contribution to be made by aquatic systems ('blue carbon") and through soils in general. We can take hope from the papers in the Proceedings of these two conferences that we are on the way.

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