



RESEARCH LETTER

On Forests and Climate Change

climate impacts – carbon sequestration – adaptation – mitigation – livelihoods – socio-economic impacts – governance – carbon sinks

An aerial photograph of a lush green valley with a small village of stone buildings. A large, white, curved, semi-transparent overlay is positioned over the center of the image, partially obscuring the forest and buildings. The text "climate impacts – carbon sequestration – adaptation – mitigation – livelihoods – socio-economic impacts – governance – carbon sinks" is written along the top and right edges of this white overlay.

SUSTAINING FORESTS FOR OUR EARTH'S CLIMATE

Climate change, forests and people are inextricably linked: sustaining forests contributes to sustaining people. Human activities are exacerbating climate change, affecting the functioning of forests and their subsequent provision

of goods and services. But forests are also part of the solution through carbon sequestration, and material and energy substitution.

CLIMATE IMPACTS

Climate change may be only one stressor on global forests, but it is an increasingly important one. While average global temperature increases are still within ranges with which forests can cope, regional differences are significant, with extremes and associated disturbances already causing visible effects in some regions. Stressors such as pollution, fragmentation, unsustainable harvesting or land use change can make forest ecosystems more vulnerable. Also, forest ecosystem changes may occur in cas-

ades, where a change in one factor propagates through the ecosystem as a result of species interactions or affects its vulnerability to other stress factors. Long-term increasing tree mortality rates associated with temperature increases, droughts and or insect attacks have been found in boreal and temperate forests in western North America. Increased levels of tree mortality following drought episodes have also been detected in multiple tropical forests as well as in Europe.

IMPACTS BY REGION: TROPICAL, TEMPERATE AND BOREAL

There are significant regional differences with respect to the impacts of climate change on forests, partly because climate change manifests itself in different ways in different regions. These variations relate to the impact of carbon dioxide on productivity, but also to variations in droughts, temperature increases, storm events, etc. For instance, in temperate forests productivity increases have been observed, while in Mediterranean regions droughts have increased, and insect outbreaks and fire increases have been observed in boreal forests. Shifts to drier forest types are predicted in the eastern Amazon. Also earlier budburst has been observed in many regions around the world with the early onset of spring.

ADAPTATION OF SPECIES AND TREES

Tree species display an enormous plasticity and they respond to climate change through genotypic adaptation and phenotypic plasticity, by moving out of unfavourable and into favourable climates, or by going locally or globally extinct. Trees have always shown this adaptation capacity to weather and climate changes in the past. However, the main concern is the speed at which this has to happen

now. This can be short term physiological adaptation, or longer term genetic adaptation through selection. Genetic adaptation can result in the same species in a next generation, but a more adapted population, for example a drought-resistant population. More drastic adaptation of the forest ecosystem can result in an altogether different tree species mix in the next generation.

IMPACTS ON PEOPLE

Climate change causes different types of impacts on human populations, and forest-related activities in all parts of the world. Forest-dependent communities will be, or are already, facing changes concerning their livelihoods, employment and natural environments. Even non-forest-dependent communities around the world will be impacted in different ways. Many benefits from forests, such as the provision of recreational areas or non-wood forest products, may be threatened. In some cases, the many cultural values of forests such as traditional uses of medicinal plants may also be threatened because of the possible changes in forest environments, flora and fauna.

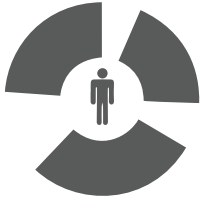
In some cases, climate change may also bring positive benefits such as longer and warmer summers in very northern locations resulting in more opportunities for outdoor recreational activities.

In those countries where the national (formal or informal) economy depends on forests to a significant extent, impacts may be substantial and diverse. Industries may move to other regions of the world, competition for traditional wood fuels may occur, etc. But socio-economic impacts will also be felt in those countries that seemingly do not depend on forests for their gross domestic product (GDP) as these countries will still see competition for raw materials, price increases in products, etc.

FORESTS: A CARBON SINK

Forests are currently a net sink for carbon at the global scale. Between 2000 and 2007, intact and re-growing forests sequestered 2.6 Pg C per year globally. The carbon taken up by intact and re-growing forests was counterbalanced by a release due to land-use change of 1.1 Pg C

per year over this same period essentially from tropical deforestation and forest degradation associated with logging and fire, resulting in a net carbon balance for global forests of 1.5 Pg C per year.



KNOWLEDGE GAPS

Forests are highly diverse and dynamic ecosystems, and are significantly influenced by human activities; changes can thus not always be attributed to climate change. Detecting early signals of climate change impacts and possibly so-called 'tipping points' in ecosystem functioning remains an important challenge. Monitoring efforts are still fragmented, measuring techniques diverse, and data scattered and un-harmonized.

We know very little about adaptation capacities that remain uneven with large variations in the ability of different species' groups to follow changes in climate through range shifts.

The future of forests as a carbon sink is unclear. The carbon taken up by intact and re-growing forests appears to have stabilized compared to the 1990s, after having increased in the 1970s and 1980s; the terrestrial carbon sink therefore, seems to be weakening. The drivers behind the forest carbon sink vary greatly across regions. They include forest re-growth and stimulation of carbon sequestration by climate change, rising atmospheric CO₂ concentrations and nitrogen deposition.

Finding the right balance between the role of forests in carbon sequestration versus their role in material and energy substitution remains a significant challenge. For example, producing biomass for bioenergy can be considered beneficial because of its carbon neutrality (if new trees are subsequently planted), but it does not solve issues such as the overall carbon debt, impacts on the forest sector through competition for raw materials, or overall pressure on forest ecosystems.

Forest management plays a role in climate mitigation in many ways, depending on the region and on the other goods and services to be produced. In the long term, a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustainable yield of timber, fibre or energy from the forest, will generate the largest sustained mitigation benefits.

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GOVERNANCE AND REDD+

The Kyoto Protocol acknowledged the key role that forests play with respect to climate, and early discussions focussed on measures such as afforestation, reforestation and reducing deforestation as a means of reducing overall CO₂ emissions. However, the complexity in designing rules and guidelines for reporting and the delays in decisions under the UN Framework Convention on Climate Change (UNFCCC) led to forest projects nearly being removed from the discussions. Later, political attention shifted to REDD+: reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries. The original idea was to contribute to climate change mitigation by creating incentives for developing countries to keep their forests standing, as deforestation is an important cause of CO₂ emissions. Also on this topic, political negotiations appeared to be slow and related research became broader: including on governance capacity, linkages with related policies, and the environmental and social impacts of REDD+.

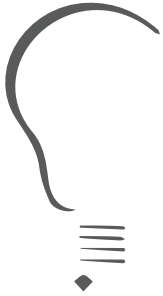
New modes of governance may be needed to lift international negotiations out of a deadlock. These should include clear incentives for local governance, institutional capacity building and practical measures.

IUFRO'S TASK FORCE "FORESTS AND CLIMATE CHANGE"

This Research Letter summarizes the findings of IUFRO's Task Force "Forests and Climate Change" between 2011 and 2014. The Task Force particularly focused on climate change impacts on forest ecosystems (including insects and pathogens) and forest-dependent people; feedbacks between land cover dynamics, forest disturbance processes and climate change; options for adaptation and trade-offs between adaptation, conservation, and/or socio-cultural needs; REDD+ and other opportunities for carbon mitigation, including governance and institutional arrangements.



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LESSONS LEARNED

Environmental changes, climate change, and geopolitical changes are closely interlinked. Although a complex global problem, climate change is felt very locally. At present we fail to fully understand the scale of the impacts, or how they will differ in time and space.

The degree to which present and future forest ecosystems will be able to deal with climate change and adapt to it is also highly uncertain.

The socio-economic impacts of climate change on traditional forest-dependent communities as well as on indirectly-dependent nations will be significant. Competition for raw materials will further increase.



CONCLUSIONS

The full scale of climate benefits from forests are neither understood nor tapped. Optimal uses of raw materials need to be advocated. Monitoring efforts are fragmented, and observation methods that are ground-based need to be more closely linked with Earth Observation tools.

Governance from international to local levels is not yet ready to deal with climate change, or to stimulate adaptation. New governance models need to be found.

