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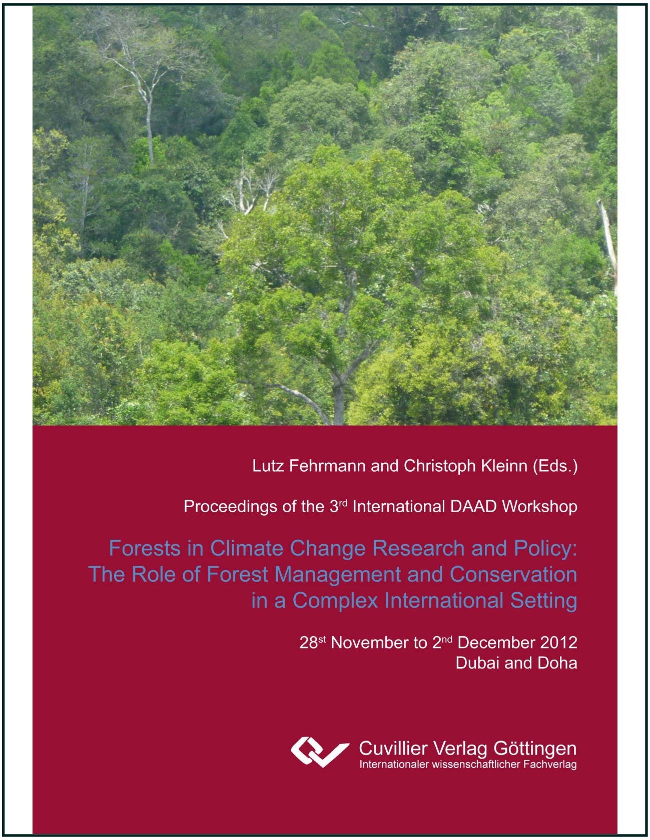
Forests in Climate Change Research and Policy: The Role of Forest Management and Conservation in a Complex International Setting



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Forest Management and Climate Change

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Abstract

Global change in particular is a threat for long living ecosystems like forests. In addition to the worldwide dramatic losses of forest land the question remains whether and how trees will react to global warming and drought. Next to this man-made threat, the frequencies of forest fires and pest outbreaks have increased, too, while often forests of high ecological value are affected. As a consequence, these forests shifted from carbon sink to carbon source and thus emit additional greenhouse gases. Hence, it is a world-wide challenge to develop efficient adaptation strategies to climate change, to prevent the ongoing decline of forest ecosystems, and to reduce the global change effects. From the forest management perspective, three strategies are discussed:

1. Reduction of deforestation and degradation (no shifting cultivation, etc.)

2. Active conservation of forests by sustainable forest management and forest protection

3. New sequestration potential by afforestation and reforestation (including increase of timber stock in existing forests)

High hopes are placed in the strategy "carbon sequestration through afforestation activities". But to even achieve a carbon balance, it will be necessary to bind some 4 billion tons of carbon and therefore about 4 billion hectares would have to be afforestated. This is an area that roughly corresponds to the current forest area of the earth.

1 Why climate change can be a major problem for forests?

The environmental conditions of climate and soil are normally regarded as constant ecological factors. For some centuries, forest managers made their decisions under the assumption that the site conditions would not change significantly during the following decades. This condition is much more important for management decisions in forestry than in agriculture because the rotation period is not one or two years as for wheat, corn and potatoes, but in most cases far above one hundred years. In Germany the traditional rotation periods are up to 100 years for Norway spruce, 120 to 140 years for Scots pine, at least 140 years for European beech and Sessile oak that can grow for more than two centuries, in some cases. Therefore, it is obvious that the risk for a forest stand is much higher than for an agricultural crop due to its long rotation periods. Risk factors for long term management decisions do not only include the uncertainty of tree species selection for specific sites (particularly drought resistance), also indirect global change effects, like the expected increasing pressure of biotic damages (i.e. bark beetles) will make it more difficult to reach the planned harvest age. The risk of a decision for a specific tree species or tree species mixture increases with the rotation period. This problematic context is an important reason for the phenomenon that more than 7 million hits are offered in Google when you search for the combination of “climate change” and “forest management”.

Furthermore, forests play a very special role in the global greenhouse discussion: on the one hand, they can function as effective storage for atmospheric carbon (forests as carbon sink), on the other hand, they are a dramatic carbon source due to a large scale severe mismanagement of forest land.

2 What is changing?

Meanwhile, there is no doubt among reputable scientists and politicians that global change is a real phenomenon. In particular, global warming is the most often discussed critical meteorological factor. Worldwide, the average annual temperature increased by 0.7 °C from 1900 to 2000 and eleven of the past twelve years rank among the twelve warmest in the instrumental record of global surface temperature since 1850! Until 2100, the increase of temperature is expected to range between 1.4 and 5.8 °C and it is unclear how existing tree species forming our forests will react.

Beside other factors, global change is responsible for a significant increase of natural catastrophes in the recent past, with remarkable economic consequences: The insurance of the insurances, the Munich-RE (reinsurance company) published a report on the development of big natural disasters in Germany during the last four decades, broken down into geophysical events (i.e. earthquakes), meteorological events (storms), hydrological events (floods) and climatologic events (extreme temperatures, drought, forest fire). In the ten years of the 1970ies a total number of 109 disasters was listed, in the 1980ies the number increased up to 128 events, in the 1990ies it reached 206 events and during the first decade of the new century 267 disastrous events were recorded. The most frequent events are storms; about 70% of all listed disasters are strong storms with great economic consequences. With four dramatic storm events within this period of 40 years, we had the highest forest damages during the last one hundred years.

Global warming is impacted stronger than other factors by more than other impacting factors a result of the strong increase of the so called green-house gases: methane, nitrous oxide, the group of CFCs and most of all carbon dioxide. In 1997 the Kyoto conference ended with the international agreement of reducing greenhouse gases significantly in each single country. In spite of some quite successful emission reductions in a few countries, the global perspective is a disaster: The global carbon dioxide concentration is increasing faster and faster, and the increase in 2011 was the strongest since the Kyoto negotiations took place twenty years ago. For 2012 the expectations point in the same direction.

Carbon dioxide, as one of the greenhouse gases, is responsible by far for the highest share of the global warming. Therefore it is important to consider the global carbon cycle: There are three major carbon storages: the atmosphere with about 750 Gt C, the terrestrial carbon pool consisting of about 600 Gt in the biosphere (especially forests) and up to 1500 Gt in the pedosphere (soils) and finally the oceans with more than 39 000 Gt. From these huge amounts of carbon stored in the water only a very small part is located in the upper layers and has the possibility to exchange gas with the adjacent atmosphere.

These three major carbon reservoirs are connected with each other through a giant circle: Plants absorb carbon as CO_2 and thereby produce biomass, but they also respire CO_2. In a later life phase of forests, when the respiration of living plants and the decay of dead biomass increases, the balance of carbon uptake and release can become imbalanced and during decay phases, forests can even act as carbon sources. Worldwide, the exchange of carbon between the atmosphere on the one hand and the biosphere and pedosphere on the other hand is about 100 Gt of carbon per year in both directions.

The amount of carbon that circulates in the second larges loop between the atmosphere and surface water of the oceans is of a similar magnitude. All these exchanges with huge amounts of carbon circulating between the three main carbon pools don’t play a major role in the current climate change issue since these processes are balanced and are therefore in a state of equilibrium. The main problems in comparison to the mentioned large flows, are comparatively small disturbances of the carbon cycle at a magnitude of about 9 Gt/year. Such forwarded disorders, leading to a unilateral increase of CO_2 in the atmosphere, can derive from natural origins like volcanic eruptions for instance. In recent decades, however, it have been overwhelmingly anthropogenic causes, which can be seen as responsible for the increase of CO_2 in the atmosphere. Even in the early decades of the 20th century when the amount of additional CO_2 emitted into the atmosphere was less than 2 Gt, both the combustion of fossil fuels and land use change (deforestation) were to blame in roughly equal parts. From the middle of the last century, there has been a dramatic increase in the share of emissions, which is caused by burning fossil fuels.

Today the proportion of total anthropogenic carbon emissions is more than 80%. Overall the global carbon cycle, which was naturally in equilibrium, is now burdened additionally by an annual amount of currently between 9 and 10 Gt with big regional differences. This amount must be absorbed by the atmosphere, which finally results in an increasing CO_2 concentration measured at around 1 ppm / year. As consequence, the greenhouse effect - that is the increased reflection of long-wave terrestrial radiation - is intensified.

3 Is forest management a solution for the problem?

Considering first the possibility that aims to turn the screw on carbon source (discharge side), the most effective measure by far would be the reduction of emission from the combustion of fossil fuels. This is without doubt a major political challenge. Although partial success has been achieved and there is hope for more, too much optimism here is not realistic. The other option on the side of the drivers, is a reduction of carbon emissions derived from land use change, the direct result of deforestation and degradation (LULUCF = land use, land use change and forestry). At this point it is necessary to analyze the role of forestry in the context of the global carbon cycle. Forests, which cover about 3.9 billion hectares of land, hold much more carbon per unit area (up 250 t C/ha) than any other type of ecosystem.

There are three main forest management concepts for the reduction of the global climate change effects:

1. Reduction of deforestation and degradation (no shifting cultivation, etc.)
2. Active conservation of forests by sustainable forest management and forest protection
3. New sequestration potential by afforestation and reforestation (including an increase of timber stock in existing forests)

4 Reduction of deforestation and degradation

“Deforestation” can be defined as the removal of forest cover to an extent that allows for alternative land use such as pasture, urban use, or logging purposes. Deforestation is the biggest single cause of land degradation, followed by agricultural activities and overexploitation of vegetation (UNEP). Besides shifting cultivation, national settlement programs, forest exploitation for firewood, and timber, mining and energy production, deforestation is caused by ranching activities. This conversion of forested areas to non-forested land can result in arid land and wastelands. Deforestation is the most important factor increasing soil erosion the worldwide extension of which is estimated to be two billion hectares (Oldemann et al., 1991). The definition of “degradation” commonly refers to reductions in the productive capacity of the forest (from closed to open forest), which negatively affect the stand or soil, thereby lowering the biological productivity, capacity and diversity (changes in species composition).

From the perspective of land use and land use change, the reduction of deforestation and degradation is the most important factor for averting the critical development of global warming. This is mainly related to tropical and subtropical areas, but there are examples from other climate zones too. When 3,100 acres were destroyed by a huge forest fire close to lake Tahoe (USA) in July 2007, an estimated 141,000 tons of carbon dioxide and other GHGs were released into the atmosphere. This is an equivalent of 114 t CO_2 per ha or 32 t C / ha. The decay of the trees killed by the fire could further increase total emissions to 518,000 tons (3.7x more). This is equivalent to the GHG emissions generated annually by 105,500 cars. In 2006, wildfires burned nearly 10 million acres, only in the United States (emission of 340 million cars) (Malmsheimer et al., 2012).

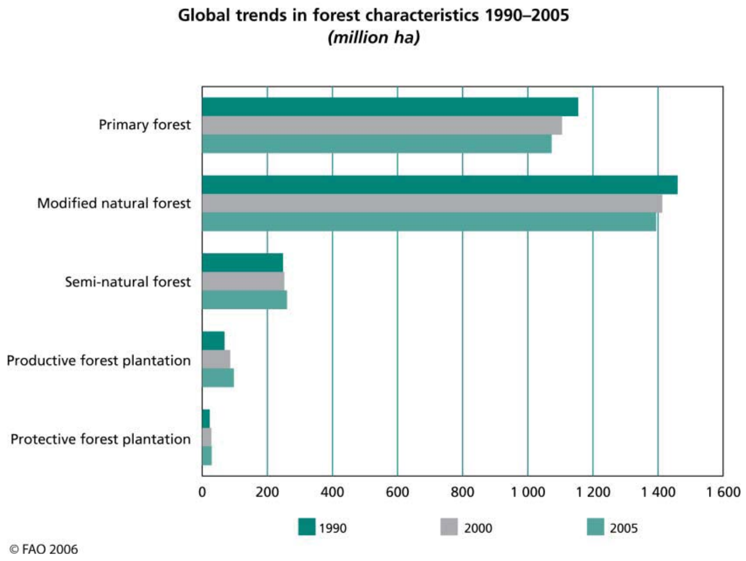

Figure 1.*Global trends of forest land change, broken down by forest types (Source FAO 2006)*

On a global scale, the loss of forest land is discouraging: According to the FAO assessment above (Figure 1), primary forests and modified natural forests show the strongest losses which cannot be compensated by the slight increase of the semi-natural forests and productive forest plantations.

5 Active conservation of forests by sustainable forest management and forest protection

Silviculture, which is as a central element of forest management, includes the complete process beginning with stand establishment, the long period of stand treatment with regulation of competition, precommercial thinnnings, pruning and thinnings, until the forests are harvested and the new forest generation can start the cycle anew. Forest protection is an important goal of forest management during the whole development. When we look at the first step within a forest cycle, the tree species selection is an efficient factor to influence the future carbon sequestration. This is one reason for the very limited number of tree species that are used for most afforestation projects world-wide. The most frequently planted fast growing tree species belong to the genus Eucalyptus and Pinus where, depending on site an annual increment, up to 40 m^3 yr^{-1} ha^{-1} can be possible.

For a *close to nature* forest management, however, it would be quite unsuitable to use unadapted fast growing tree species. Therefore, a sustainable silviculture has to accept less productivity and lower carbon sequestration. Nevertheless, tree species selection is one of the most effective silvicultural options to steer carbon fluxes with forest management methods.