Dead wood preserves carbon in forest ecosystems

Dead wood is a key structural element in all forest types that is formed by natural mortality or as logging residuals from logging operations. If forests develop beyond logging maturity age, the carbon pool continues to grow for several hundred years and such old-growth forests have large dead wood carbon pools. Recently, it has been discovered that dead wood also adds significant input to the soil carbon in boreal forests.

Dead wood is frequently incorporated into forest soils due to overgrowth by ground vegetation. This is a significant part of the soil carbon pool.

International carbon reporting

It is an obligation of all countries that have signed the United Nations Convention on Climate Change, including the Kyoto protocol, to report annually their national carbon budget, i.e. the stock and stock change subdivided on specific carbon pools. For forested areas, dead wood is one of these carbon pools.

It is a challenge to quantify the carbon stores in dead wood as both dead wood volumes and carbon densities of different dead wood type is needed. A North European network on dead wood ecosystem services has been formed to synthesize knowledge on this subject.

A first priority is to quantify carbon densities of different decomposition stages from various tree species and thereby enable countries to quantify the dead wood carbon pool in managed forests based on national forest inventory data.

Another priority is to synthesize knowledge on carbon dynamics in forests that develop as old forests. Such forests are found in nature reserves formed for biodiversity conservation but it has also been suggested that old forests should be allowed to develop as a means to sequester CO_2 from the atmosphere.

Carbon accumulation in old forests

The common use of forests is to manage the land for timber production. In such forests stands are felled at logging maturity age, which maximizes the long-term timber harvest. In an average productive forest, the logging maturity age is 100 years. Managed forests grow rapidly, sequester large amount of CO_2 from the atmosphere and the harvested wood is used for several products. The usage of wood-derived products (bioenergy, paper, building materials) eventually results in circulation of CO_2 back to the atmosphere. Managed forests have small amounts of dead wood – typically below 5 % of levels found in corresponding old-growth forests.

From a biological point of view, the logging maturity age reflects the end of a rapid youth growth period, but the normal life span of trees is typically two to three times longer. As forests grow older the trees continue to grow at a gradually slower rate, and build up further carbon stores. But no tree grows into the sky. Natural mortality from wind, competition between trees, insect or fungal attacks, and eventually senescence kill trees. The natural mortality rates vary between forest types but on average about 1 % of the trees die each year. Thus, at some point in time, which might be 200-400 years after stand renewal, the tree growth and natural mortality balance each other and the carbon store in the living biomass levels out.

In old forests, natural mortality creates dead wood that remains in the stand and decompose slowly. On average, it takes about 100 years to decompose nearly all the biomass in a dead tree. This process goes faster in temperate forests of southern Scandinavia and slower in boreal forests close to the mountains. As a consequence, the carbon store in dead wood reaches a maximum about 100 years after the carbon store in living biomass has peaked. Taken together, old forests continue to build up carbon stores in living and dead wood for several hundred years after the logging maturity age but eventually a maximum storage capacity is reached and no further carbon sequestration takes place in this pool.

Existing scientific studies indicate that in such old-growth forests approaching their maximum carbon storage capacity, the amount of dead wood is at least 10-20 times larger as compared with managed forests and it accounts for 20-40 % of all carbon in the combined living and dead biomass pool.

The North European network on dead wood has identified the challenge of predicting rates and amount of dead wood input through natural mortality in old-growth forests and quantifying the dead wood carbon stores in such forests. The specific challenge is to quantify such rates and stores in different forest types and climate zones. Such knowledge is needed to inform policy making on long-term carbon sequestration as an alternative land use option.

Buried wood

It is commonly assumed that all dead wood in forest ecosystems is completely decomposed above-ground. This is normally the case, but it is also common that partly decomposed wood is overgrown by the ground vegetation and incorporated into the organic (humus) layer of forest soils. This phenomenon is common in coniferous boreal forests and it is the normal development in certain forests types with vigorous moss growth.

Forests with poor soil drainage, that is peatland and swamp forests of different kinds, appear to be particularly important for wood burial. Such forests are common in boreal and temperate forests. From peat excavation sites in Sweden and Germany it has been found large amounts of buried wood preserved for several thousand years in peat soils. Thus, forests with peat soils represent overlooked hotspots that appear to sequester carbon in buried wood on time scale of millenia.

Preliminary analyses from network members indicate that about 20 % of all carbon from dead wood is incorporated in boreal forest soils across different forest types. In the soil, the decomposition continues at a slower rate, or even stops completely, due to lower temperature and reduced oxygen availability. It is an important challenge to quantify the amount and rate of wood burial as well as decomposition rates in different forest soil types.

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Jogeir Stokland, Norwegian Institute of Forest and Landscape Published 2015

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